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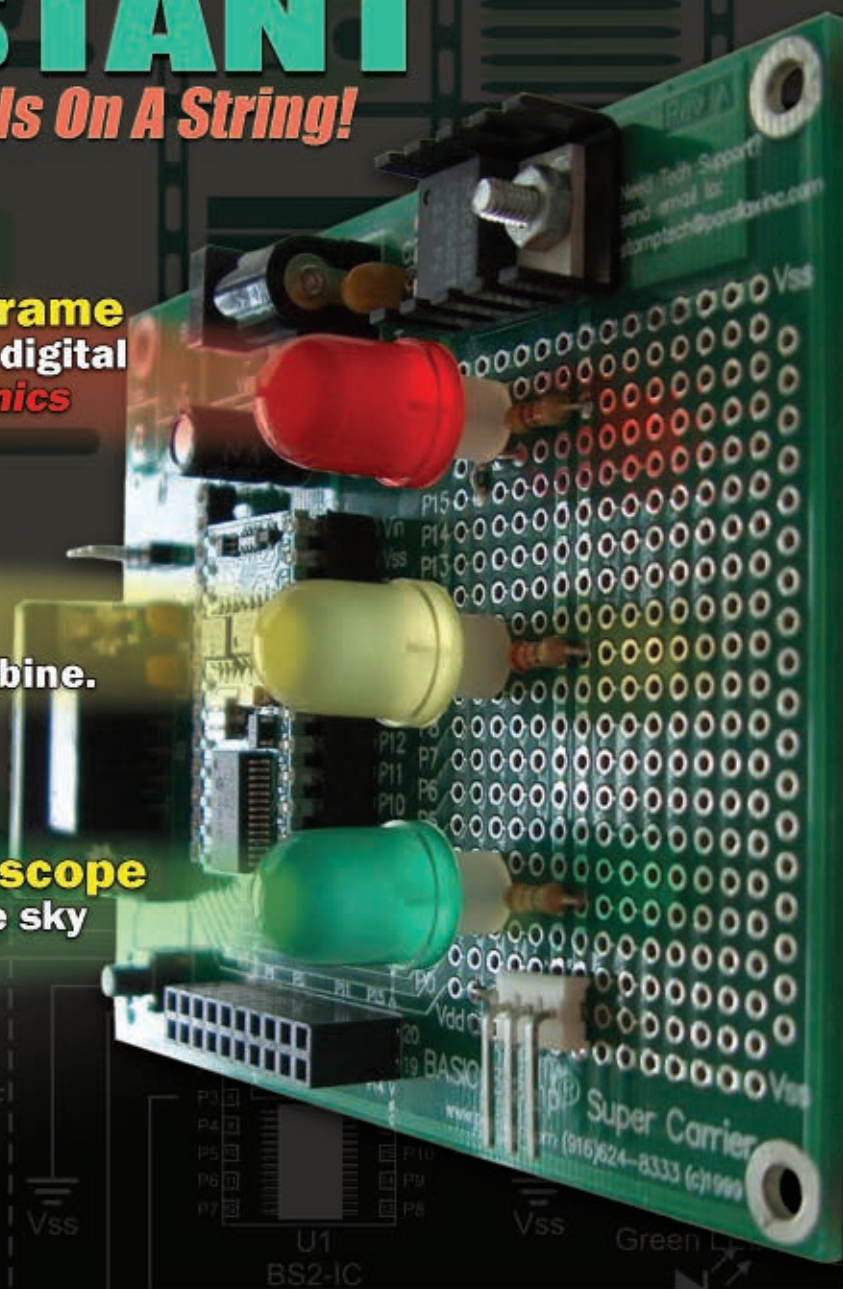
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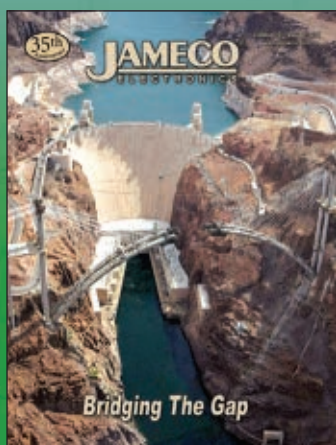
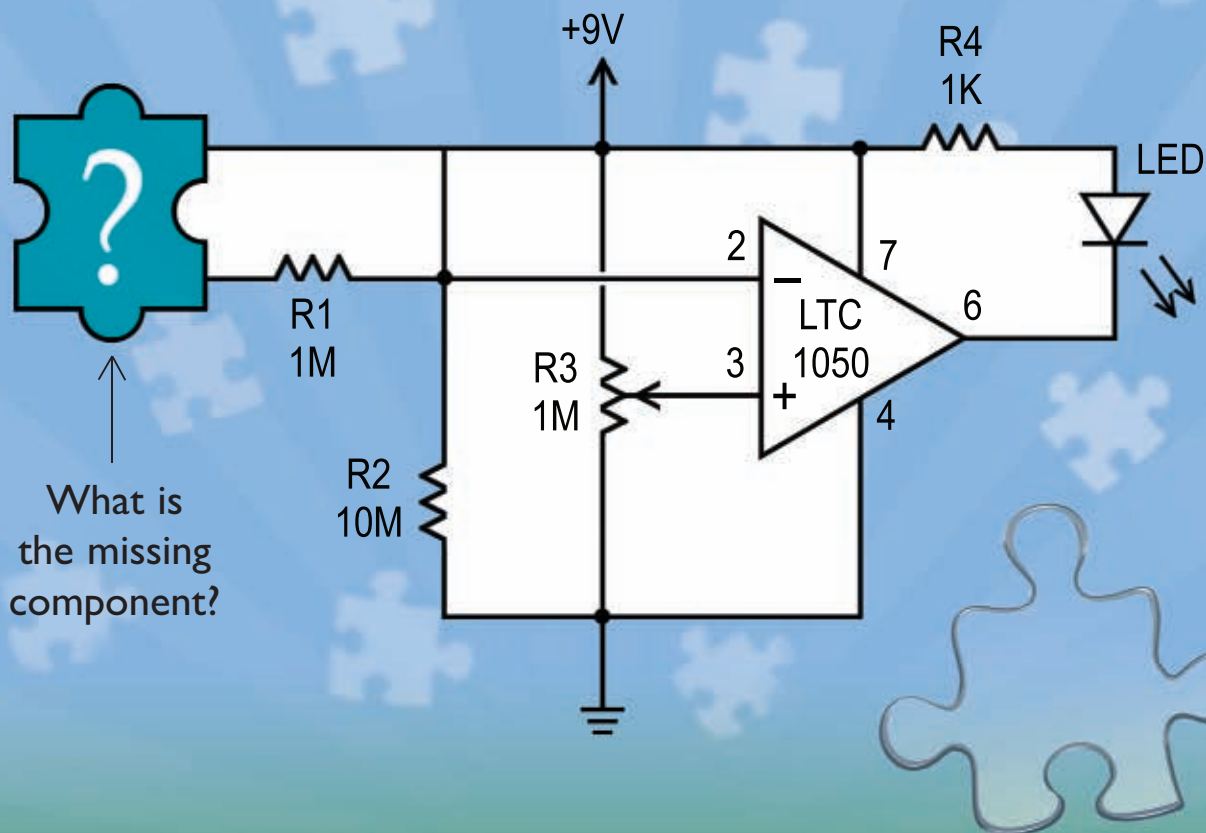


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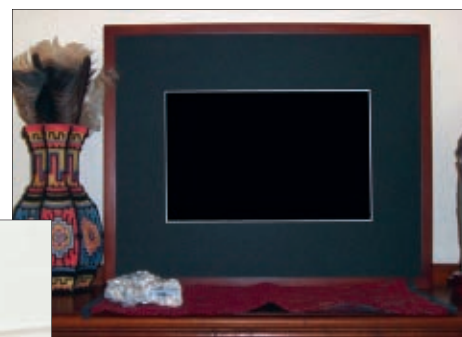
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by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

Truth in Specifications?

Given the lax inspection policies of the FDA, I don't have much faith in package labels. With the current economy, there's simply too much pressure to skimp on ingredients or falsely elevate nutritional claims. I can't prove it — I just don't have the analytical tools on hand to determine the quantity of digestible protein in a fish stick or energy bar. The same pressures on the food industry no doubt have an effect on the electronics industry. But this is more than a feeling — I've proven it to myself. A recent book project of mine involved the teardowns of two dozen electronic devices, from a stereo amplifier and ultrasonic humidifier to a power conditioner. In several cases, the teardowns revealed manufacturers were either intentionally or unintentionally misleading consumers with product specifications that were confusing, incomplete, or simply false. For example, one manufacturer listed the frequency response of their stereo amp at 20 Hz–20 kHz. You might assume this represents 3 dB points, but you'd be guessing. Without additional data, there's no way to fully evaluate the amplifier or compare its frequency response specifications with those of other amps.

Another example is the total harmonic distortion plus noise (THD+N) figure of 0.1%. Again, the issue is incompletely specifying the measurement. One of the key parameters in measuring THD+N is the bandwidth. You could assume that it's the bandwidth of the amplifier at 3 dB points, but that's not stated anywhere. As a result, the manufacturer

has quite a bit of wiggle room when it comes to delivering on the specs. One of the worst deviations from published specs was for an expensive power conditioner. The documentation stated that the device employed special high-energy MOVs with built-in thermal fuses. As a result of the teardown, however, I found ordinary MOVs — one of which was placed directly across the hot and neutral lines, without the safety factor afforded by a thermal fuse. Not only are the specifications erroneous, but the device represents a fire risk. This power conditioner didn't have a UL (Underwriters Laboratories) listing — a red flag for any consumer product. The role of the UL is to evaluate the safety of a device, not its functions or adherence to published specifications. However, when it's missing, you should be suspect of the specifications in general. So, let's say electronic device specifications are erroneous 10% of the time. What are we to do? Obviously, you can't tear down every device you buy, simply to verify the specifications. Besides, many of my teardowns refuse to be put back together again. My approach is to simply question every specification I see, especially if the device is from a no-name manufacturer. Consider that some manufacturers of audio amplifiers simply copy the specifications for the integrated amplifier chips used in their amps and apply those specifications to the entire audio system. However, chips never provide the full specs when used in a real circuit. Power may not be sufficient or properly regulated, thermal conditions may not be optimum, and the

load impedance may fluctuate with frequency (as is normal for a typical speaker). The same goes for RF wireless systems. Whether you're evaluating a piece of test gear or a consumer device, if the specifications match the theoretical performance of the underlying chips, you shouldn't trust the specifications. Test equipment is a special case, thanks to the NIST (National Institute of Standards and Technology) traceable calibration. NIST offers calibration certification for equipment ranging from temperature probes to voltmeter accuracy. I rarely pay the premium for the NIST calibration, but view the option of NIST calibration as a sign of quality. A poorly built instrument is rarely capable of performing to NIST standards. If you have stories of questionable specifications, please consider sharing them with our other readers. **NV**

Ardweeny. You'd think that's what all the big & mean Arduinos would call the smallest one. ...and you'd be right.

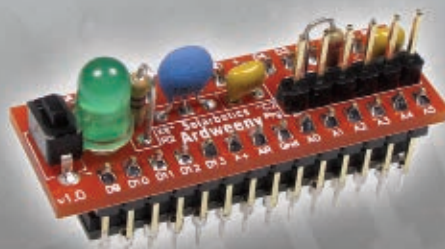
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This image is to scale (...no, seriously!)



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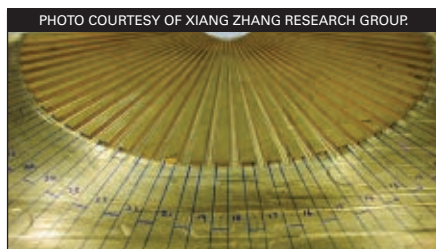
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■ BY JEFF ECKERT

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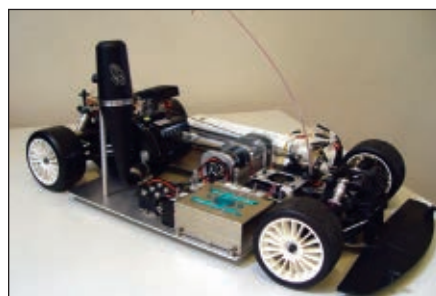
Back in 2007, Prof. Xiang Zhang and colleagues at the DoE's Lawrence Berkeley National Lab (www.lbl.gov) announced that they had achieved the "holy grail" of optical imaging using a device made of nanowires of silver and aluminum oxide. The "hyperlens" was able to use visible light to image objects smaller than 150 nm — well below visible light's "diffraction limit" of 260 nm. The hyperlens operated by transforming evanescent (near-field standing) lightwaves into propagating waves to project a high-resolution image in the far field. Now, applying the same principle to sound waves, Zhang and company have announced creation of the world's first acoustic hyperlens.

"We have successfully carried out an experimental demonstration of an acoustic hyperlens that magnifies subwavelength objects by gradually converting evanescent waves into propagating waves," he noted. "Our acoustic hyperlens relies on straightforward cutoff-free propagation and achieves deep sub-wavelength resolution with low loss over a broad frequency bandwidth."

The acoustic version consists of 36 brass fins in the shape of a hand-held fan, with each fin being 20 cm

long and 3 mm thick. The fins — embedded in a brass plate — extend out from an inner radius of 2.7 cm to an outer radius of 21.8 cm, and spread 180° in the angular direction. The current version has produced 2-D images of objects 6.7 times smaller than the wavelength of the imaging sound wave, and Zhang et al. are refining the technique to produce 3-D images. They are also working to make the device compatible with pulse-echo technology — the basis of medical ultrasounds and underwater sonar imaging systems. In time, this may translate into much more precise imaging in applications ranging from the detection of small tumors to more detailed imaging of undersea objects.

GO WITH THE FLOW?



■ One-fifth scale test vehicle for integration of an improved redox flow battery (© Hochschule für Angewandte Wissenschaften Ostfalia).

A somewhat less novel but perhaps more immediately available technology level is the redox (i.e., reduction-oxidation) flow battery, actually invented back in 1973 by NASA researcher Dr. Lawrence H. Thaller. In a redox battery, two fluid electrolytes flow through porous electrodes separated by a membrane that allows the passage of protons. This results in a charge exchange and a current flow over the electrodes.

The neat thing about redox batteries is that they can be "recharged"

simply by swapping out their electrolyte fluids. That feature makes them highly desirable for use in electric vehicles, as it could make refueling much faster and easier than trickling in an electrical recharge. The problem has been a lack of charge capacity, which is about one fourth that of lithium-ion batteries. However, in a recent research report, the Fraunhofer Institute for Chemical Technology (www.fraunhofer.de) announced the creation of a prototype cell that it claims increases the capacity by as much as 500% — approximating that of lithium-ion.

A one-fifth scale model vehicle was demonstrated on a test rig last October at the Munich eCarTech, but the concept is not quite ready for deployment in the real world. The next challenge is to assemble and optimize a pack of cells into a battery and scale it up sufficiently. In the coming year, the researchers hope to integrate the new battery — with four times greater mileage — into a model vehicle, so stay tuned.

HUMONGOUS HYBRID

In recent years, hybrids have been ramped up from the relatively puny Toyota Prius (curb weight 2,765 lb) to the hefty Escalade (5,932 lb), but when it comes to hybridizing a huge vehicle, it's tough to beat the U.S. Navy's Makin Island (dead weight 13,002 tons), commissioned last October. It's the first amphibious assault ship built with a hybrid propulsion system, consisting of twin LM2500+ gas turbine engines (35,000 hp each), two 5,000 hp variable speed propulsion motors (fitted with two 16.5 ft dia., variable pitch Rolls Royce props), and six 4,000 kW diesel generators. On its maiden voyage, the hybrid system

saved about 900,000 gallons of fuel, which would have cost the taxpayers more than \$2 million (and would take more than two months to pump from your neighborhood gas pump). The ship operates on electric power about 75 percent of the time, which should save about \$250 million over its projected lifetime.

COMPUTERS AND NETWORKING

RUGGED MINI PC OFFERS REMOVABLE MEDIA



PHOTO COURTESY OF US NAVY.

■ Stealth's LPC-395F, for rough industrial/commercial environments.

Late last year, our Canadian friends at Stealth Computer (www.stealth.com) introduced the LPC-395F: a rugged, small footprint, fanless computer that includes front-loaded slots for both removable 2.5" SATA hard drives and compact Flash media. The fanless machine is designed for applications such as digital sign, mobile/field deployment, process and discrete control, automation, human-machine-interface, data acquisition, and machine control where it is important to be able to swap out drives without removing and disassembling the computer box. The guts are based on an ATOM N270 processor, up to 2 GB memory, and up to 500 GB of mass storage. I/O connectivity includes twin gigabit LAN, four USB 2.0, and two RS-232 ports, plus one DVI and standard audio connections. You can also go for the optional Wi-Fi 802.11g. The box measures only 6.54 x 6.18 x 1.89 in (16.6 x 15.7 x 4.8 cm). It may be a bit pricey for your home projects

with a base quoted at \$795, but if you need the ruggedness and convenience, it might be worth a look.

WORLD'S FIRST USB 3.0 RAID DRIVE



■ SuperTalent's USB 3.0 drive will be offered in 32, 64, and 128 GB versions.

Okay, so you don't own any computing devices that offer "superspeed" USB 3.0 functionality. But someday you will, because the 4.8 Gbps maximum data rates, increased bus power, and full-duplex data transfers will be raising their skirts and winking at you. In the meantime, why not make your next USB drive 3.0 compatible so you can take advantage of it whenever you upgrade your computer or digital camera? At least that's what the folks at Super Talent Technology (www.supertalent.com) want to know.

In November, the company introduced its SuperSpeed USB 3.0 RAID Drive, said to support transfer speeds of up to 320 MBps — ten times faster than USB 2.0 drives. The compact (95 x 37 x 13 mm, or 3.7 x 1.5 x 0.5 in) Flash drive comes in three capacities: 32, 64, and 128 GB; and uses patented "multiple pairs of differential serial data lines technology" for optimal performance. Of course, you won't get 3.0 speeds on your 2.0 devices, but it seldom hurts to plan ahead. At this moment, no price info has been made available, but that's not a big problem given that we couldn't find any retailers who are offering them yet. Maybe by the time you see this ...

TIMELESS TECHNOLOGY

If you're one of the 25 million people who bought a Betamax VCR

back in the 1970s and 1980s, by now you're probably getting pretty steamed about the short life of the cartridges. After all, it's been only 30 years or so, and already you're losing those treasured episodes of the Donny and Marie show. Well, don't look now, because it's happening to you again. You may think those home-recorded discs will last forever but, in fact, CD-R and DVD-R manufacturers generally specify a shelf life of only five to 10 years, and that under optimal conditions of temperature, humidity, and exposure to light. The folks at Cranberry (www.cranberry.com) have an even more pessimistic view, opining that your discs are likely to last no more than two to five years, and that even the gold DVDs "are degrading as fast as the silver ones." Kodak (www.kmpmedia.com/premium/gold-preservation-discs) appears to strongly disagree with that, claiming that its CDs will last up to 300 years and their DVDs 80 to 100 "with proper handling." But what if even that isn't enough? Consider that if Czar Peter the Great had recorded the first Russian state budget on a gold CD back in 1710, you probably wouldn't be able to read it today.

But hang on, because Cranberry now offers the DiamonDisc which is predicted to be readable even 1,000 years from now. The product holds an unremarkable 4.7 GB of data but is unharmed by temperatures up to 176°F (80°C) and contains essentially no materials that can deteriorate. The secret is the use of a higher-intensity laser that etches data into a "diamond-like" synthetic stone surface containing no dye, adhesive layers, or reflective materials. The drawback is that they're not cheap, starting at \$35.95 for a single disc and dropping only to \$29.95 in quantity. And you can't even burn them yourself unless you spring for a \$5,000 drive. Consider the immortality of it all: With DiamonDisc — even in the next millennium — posterity may still be watching your peculiar little home movies on their 1,000 year old computers.

CIRCUITS AND DEVICES

TEXT-TO-SPEECH HANDHELD INTRODUCED



■ The Intel Reader aids people with vision problems.

Text-to-speech conversion isn't a new concept by any means, but last November, Intel introduced it in a compact, handheld package called the Intel® Reader. The device is aimed at the people — 55 million of whom live in the USA — who have dyslexia or other vision problems. As you might expect, it converts printed text to digital text, and then reads it aloud to the user. It includes an Atom processor-driven 5 Mpixel camera that allows users to point at, shoot, and listen to the text. Used with an Intel Portable Capture Station, large amounts of text — even up to an entire book — can be captured for processing later. With a reported

price tag of \$1,499, it isn't for people who are both blind and poor, but Intel is working with the Association of Assistive Technology Act Programs, the Council for Exceptional Children, Lighthouse International, the National Center for Learning Disabilities, and the National Federation of the Blind to help reach as many people as possible. For details and a video, visit reader.intel.com.

THERE'S AN APP FOR THAT, TOO

You may never have had a problem sensing whether a person in the airline seat next to you is emitting ammonia or methane, but Jing Li, a scientist at NASA's Ames Research Center (www.nasa.gov/centers/ames/home/index.html) and some researchers in the Department of Homeland Security (www.dhs.gov) have developed a device to make it less unpleasant. Designed to be plugged into an iPhone to collect, process, and transmit sensor data, it is able to detect and identify low



PHOTO COURTESY OF NASA AMES RESEARCH CENTER.

■ NASA's cell phone chemical sensing device, so far unavailable to the public.

INDUSTRY AND THE PROFESSION

IBM JOURNALS AVAILABLE

In 1957, the *IBM Journal of Research and Development* was founded, to be followed in 1962 by the *IBM Systems Journal*. The latter was eventually merged into the former and is one of the number-one cited publications covering the latest advancements in computer science. For those who are interested in such things — and particularly IEEE members — the good news is that all papers ever published in either journal will be made available this year in the IEEE Xplore digital library (ieeexplore.ieee.org). Non-members can search and access abstracts for free, register to receive table of contents alerts, and purchase full PDF documents. It appears that members can go straight to the documents, but that is unverified, as yours truly long ago decided to reallocate the \$175 annual membership fee to Anheuser-Busch.

concentrations of airborne chlorine gas, as well as the aforementioned ammonia and methane. The device senses chemicals in the air using a "sample jet" and a multiple-channel, silicon-based sensing chip (consisting of 16 nanosensors) and sends data to another phone or a computer via a telephone network or Wi-Fi. The only problem is, a user will have to act quickly, before the pilot orders passengers to switch their phones off. **NV**

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SECURITY & PC KITS FOR ELECTRONIC ENTHUSIASTS

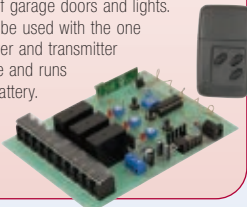
NEW KIT

UHF ROLLING CODE REMOTE SWITCH KIT

KC-5483 \$58.00 plus postage & packing

High-security rolling code 3-channel remote control for keyless entry and control of garage doors and lights. Up to 16 transmitters may be used with the one receiver. Kit includes receiver and transmitter with 3 button key fob case and runs on a 12V remote control battery.

Additional UHF Rolling Code Transmitter Kit KC-5484 \$23.25



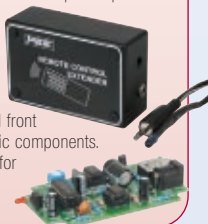
IR REMOTE EXTENDER MKII KIT

KC-5432 \$15.75 plus postage & packing

Operate your DVD player or digital decoder from another room using its remote control. This improved model picks up remote control signals and sends it via a 2-wire cable to an infrared LED located close to the device. Features fast data transfer for pay TV remotes using the Pace 400 series decoder.

Kit supplied with case, screen printed front panel, PCB with overlay and electronic components.

- Required: 9VDC and 2-wire cable for extending the IR-Tx lead (use WB-1702).



EMERGENCY 12V LIGHTING CONTROLLER

KC-5456 \$40.75 plus postage & packing

Automatically supplies power for 12V emergency lighting during a blackout. The system is powered with a 7.5Ah SLA battery which is maintained via an external smart charger. Includes manual override and over-discharge protection for the battery. Kit supplied with electronic components, screen printed PCB, front panel & case. Charger and SLA battery available separately.

Featured in EPE November 2009



5M IR LIGHT BEAM KIT

KG-9094 \$8.75 plus postage & packing

With a range of about 5 meters, this kit will indicate using an LED when a person or object interrupts the infrared light beam. Kit supplied with PCB, and electronic components. 9-12VDC operation.



RFID SECURITY MODULE RECEIVER KIT

KC-5393 \$54.50 plus postage & packing

Radio Frequency Identity (RFID) is a non-contact method of controlling an event such as a door strike or alarm etc. An "RFID Tag" transmits a unique code when energised by the receiver's magnetic field. As long as a pre-programmed tag is recognised by the receiver, access is granted. This module provides normally open and normally closed relay contacts for flexibility. It works with all EM-4001 compliant RFID tags. Kit supplied with PCB, tag, and electronic components.

As published in EPE August 2007



SMS CONTROLLER MODULE KIT

KC-5400 \$33.75 plus postage & packing

Control appliances and receive alert notification from anywhere. This kit can control up to eight devices by sending plain text messages and simultaneously monitors four digital inputs. It works with old Nokia handsets such as the 5110, 6110, 3210, and 3310, which can be bought inexpensively. Kit supplied with PCB, pre-programmed microcontroller and electronic components. Requires a common Nokia data cable found in many retail stores.

As published in EPE March 2007



50 METER IR LIGHT BARRIER KIT

KG-9196 \$29.00 plus postage & packing

Covering up to 50 meters, this light beam relay is ideal for protecting areas that have wide entrances, including driveways, shops, offices and storerooms, etc. Once the beam is broken the relay will trigger and an onboard LED will illuminate. Kit includes PCB, infrared transmitter diodes, receiver transistor, magnifying lens and electronic components.

The transmitter requires a 9VDC plugpack & the receiver requires 12VDC plugpack (not included).



NEW KIT

SD/MMC CARD WEBSERVER IN A BOX

KC-5489 \$52.25 plus postage & packing

Host your own website on a common SD/MMC card with this compact Webserver In a Box (WIB). It connects to the Internet via your modem/router and features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 interface along with four digital outputs and four analogue inputs. Requires a SD memory card, some SMD soldering and a 6-9VDC power adaptor. Kit includes PCB, case and electronic components.

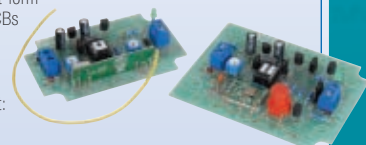


433MHZ REMOTE SWITCH KIT

KC-5473 \$26.25 plus postage & packing

Featuring a transmitter and receiver, this kit serves as a remote control of practically anything up to a range of 200m. The receiver has momentary or toggle output with adjustable momentary period. Up to five receivers can be used in the same vicinity. Short-form kit contains two PCBs and specified components.

Extra transmitter kit: KC-5474 \$13.50



INFRARED FLOODLIGHT KIT

KG-9068 \$17.50 plus postage & packing

Enables your CCD camera to see in the dark - 32x infrared LEDs illuminating an area up to 5 meters. Kit includes gold-plated/solder masked PCB, 32x infrared LEDs and electronic components.

- Not suitable for CMOS cameras.



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Note: Products are dispatched from Australia, so local customs duty & taxes may apply. Prices valid until 31/1/10



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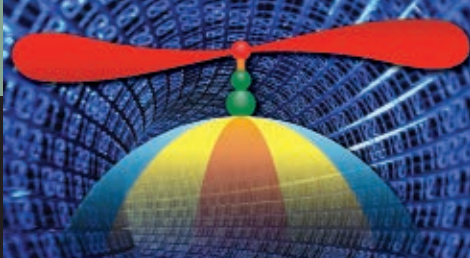
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SPIN_{ZONE}

ADVENTURES IN PROPELLER PROGRAMMING

■ BY JON WILLIAMS

SIRCS, PROPELLER STYLE!

I have a really cool friend named Lou who designs camera support accessories — one of those accessories being a nice pan/tilt control head for film and video cameras. I worked with Lou to redesign the electronics for a product to use the SX48. Things are going well and I suggested to Lou that he consider the Propeller for the next generation; I felt like Spin would suit him more than SX/B and allow him to add features without relying on me or anyone else. Immediately thereafter, Lou called and asked if — in a future version of that product — we could add pan/tilt control from a simple TV remote. It didn't take long (only an hour or two) to make it work, and I'm happy to have SIRCS reception and transmission in my Propeller toolbox. Now you can, too.

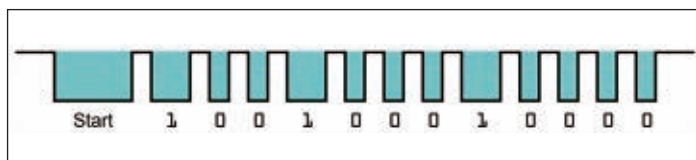
THE SIRCS PROTOCOL IN REVIEW

In the [very unlikely] event that you've never seen or heard of the SIRCS (Sony IR Control System) protocol, I'll explain: SIRCS is a pulse-width modulated protocol transmitted over an IR beam that is primarily used in the consumer electronics arena (TVs, VCRs, DVD players, etc.).

On the receiving side of an SIRCS-based system, a demodulator provides an active-low output to the processor, as shown in **Figure 1**. The SIRCS stream begins with a Start bit that is 2.4 ms wide. This bit — as with all other bits — is followed by a 0.6 ms pad. The data bits are transmitted LSB-first and are width-encoded with a "1" bit that's 1.2 ms wide and a "0" bit that's 0.6 ms wide. The entire frame is transmitted within a 45 ms window. Most remotes will repeat the SIRCS code at least three times to ensure it has been received (though I've noted that my Sony still camera remote actually transmits a given code five times).

Note that different devices use different length codes.

■ **FIGURE 1.** SIRCS Protocol.



In my experience, TV codes tend to be 12 bits, while more advanced devices like DVD players use 20-bit codes. The IR code has two elements: a device code and a key code. In the 12-bit system, the device code is five bits and the key code is seven bits. In the 20-bit system, the device code is eight bits and the key code is 12 bits. As you can see, the 20-bit system provides for significantly more key codes. This makes sense considering the increasing complexity of consumer electronics devices.

DECODING SIRCS WITH THE PROPELLER

The first bit of great news when using the Propeller is that we can drop SIRCS decoding into its own cog so we don't have to worry about interrupt timing (which doesn't exist on the Propeller, anyway), a code coming in when we're not ready for it, or "blocking" the rest of the program while waiting for the user to press a key on the remote.

Let's jump right in, shall we? You may remember from the DMX512 project that in addition to using a separate cog, we also took advantage of the multi-purpose timers within each cog to simplify the code. We're going to do that again.

```
rxsircs      mov      ctra, NEG_DETECT
```

```

        mov     frqa, #1

        mov     ctrb, FREE_RUN
        mov     frqb, #1

waitok   rdlong  tmp1, okpntr    wz
        if_nz   jmp     #waitok

waitstart waitpeq irmask, irmask
        mov     phsa, #0
        waitpne irmask, irmask
        mov     phsb, #0
        waitpeq irmask, irmask
        cmp     START_BIT, phsa wc
        if_nc   jmp     #waitstart

```

As you can see, we're going to use both counters. Counter A is going to be set up in negative detect mode to measure the width of incoming bits. Counter B will be used in free-run mode to keep track of frame timing.

At the label **waitok**, the program reads a flag from the hub. This allows the user to enable the SIRCS decoder when desired. A non-zero value in this flag allows the program to drop through to **waitstart** where — as you've no doubt guessed — we will wait for the 2.4 ms start bit.

At the beginning of this section, we can use **waitpeq** and the IR input pin mask to wait for that input to be high. We need to start this process while the line is high to make sure that we can measure the whole bit — we don't want to come in late and get an inaccurate measurement. When the line is high, we clear PSHA and then wait for the line to drop with **waitpne**.

When the line goes low, we clear the PHSB register. Why? Well, we're assuming at this point that we've found the leading edge of the start bit and we need to clear the PHSB register which will be keeping track of the frame duration. Once the line goes back high, we use **cmp** to test the width of the bit. If it's a valid start bit, then we drop through. Otherwise, we jump back to **waitstart** and test the next bit.

With the start bit detected, the next step is to collect the bits that comprise the device/code.

```

        mov     irwork, #0
        mov     bits, #0

checkframe cmp     MS_044, phsb    wc
        if_c    jmp     #irdone

waitbit    test    irmask, ina     wz
        if_nz   jmp     #checkframe

measurebit mov     phsa, #0
        waitpeq irmask, irmask
        cmp     ONE_BIT, phsa    wc
        rcr     irwork, #1

```

```

        add     bits, #1
        cmp     bits, #20        wc
        if_b    jmp     #checkframe

irdone     mov     tmp1, #32
        sub     tmp1, bits
        shr     irwork, tmp1

report     wrlong  irwork, codepntr
        wrlong  bits, bitspntr
        wrlong  DONE, okpntr

        jmp     #waitok

```

Our decoder has no way of knowing what's being pointed at it, so it keeps track of the code received (*irwork*), as well as the number of bits received (*bits*) — both values will be provided to the calling program.

It may seem like odd placement, but the top of the bit receive loop (at **checkframe**) actually tests the frame timer (in PHSB) to see if the frame is complete. I'm using 44 milliseconds as the test value for what is supposed to be a 45 ms frame. It's okay to be a little short because even if all the bits of a 20-bit code were "1," it would still only be 39 milliseconds.

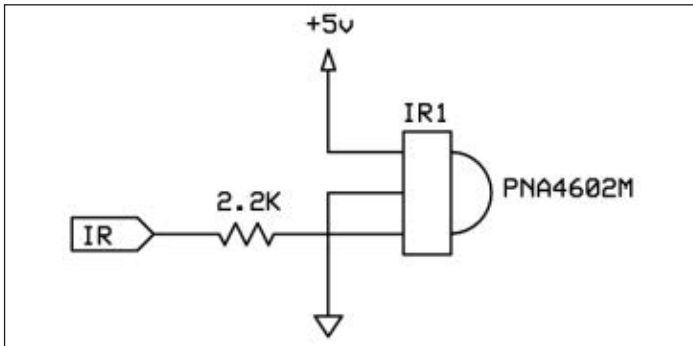
If the frame is still active, we test the line for a new bit (line is low). While the line remains high, we have to loop back through **checkframe** so that the end is handled correctly. Once the line does drop for a new bit, we clear PHSA and then wait for the line to go back high. The width of the newly-captured bit is compared to the timing for a 1 bit, with the result written into the Carry flag. This bit is then moved into *irwork* with **rcr** (rotate carry right). With the bit saved, we increment the bit count and if it's less (**if_b**) than 20 bits, it jumps back to **checkframe**.

Once we've received 20 bits or the frame timer reaches 44 milliseconds, the program moves to **irdone** where we clean up the result. Since the bits come in LSB first, we had to shift them in from the left (toward the right) — this means that our result is MSB-aligned in *irwork*. By subtracting the number of bits received from 32 (bits in a long), we can correct and LSB-align the result. One of my favorite aspects of PASM is that we can shift a value any number of bits with a single instruction.

Finally, the result in *irwork*, the number of bits

► BILL OF MATERIALS

Item	Description	Supplier/Part No.
IR1	PNA4601M	Parallax 350-00014
R1	2.2K	Mouser 291-2.2K-RC
IR2	IR LED	Parallax 350-00003
R2	100 ohm	Mouser 291-100-RC
PCB	Propeller Demo Board	Parallax 32100



■ FIGURE 2. SIRCS Sniffer Circuit.

received, and the enable flag are written back to the hub. The flag is set to false so the code doesn't run until the calling program tells it to.

SPINNING UP AN SIRCS "SNIFFER"

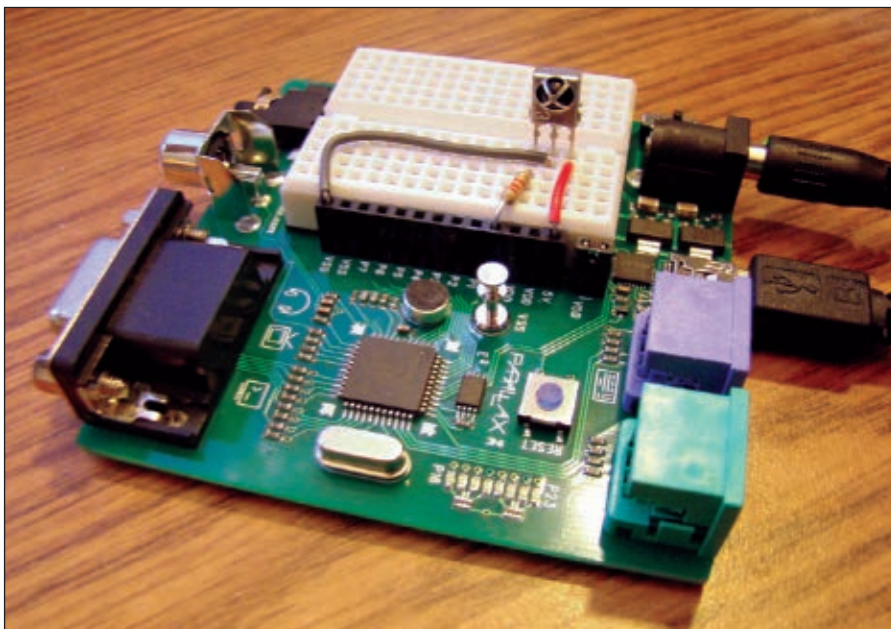
A year ago, I created an SX-based SIRCS "sniffer" program to determine the various codes of the Sony remotes that seem to run wild in my home — it now makes perfect sense to create a Propeller version of that. The code is really simple. In addition to the SIRCS receiver object, we'll use a serial output object to send the detected SIRCS codes to a terminal program (I prefer the Parallax Serial Terminal for my Propeller experiments). Here's the code:

```
pub main | code, bc

  ir.init(0)
  term.init(30, 115_200)
  waitcnt(clkfreq / 1_000 + cnt)

  term.str(string( {
```

■ FIGURE 3. SIRCS Sniffer Output.



```
} CLS, "SIRCS Sniffer", CR, CR))

repeat
  code := ir.getir
  bc := ir.bitcount
  case bc
    12:
      term.str(string("12 :: "))
      term.bin(code >> 7, 5)
      term.tx(".")
      term.bin(code, 7)
    20:
      term.str(string("20 :: "))
      term.bin(code >> 12, 8)
      term.tx(".")
      term.bin(code, 12)
  other:
    if bc < 10
      term.tx("0")
    term.dec(bc)
    term.str(string(" :: "))
    term.bin(code, 32)
  term.tx(CR)
  waitcnt(clkfreq / 4 + cnt)
```

The main loop of this program calls the .getir() method from the IR object. This method enables the SIRCS receiver, waits for a code to show up, and then returns it to the caller. At this point, there is a valid bit count available as well, and this can be acquired using the .bitcount() method.

As you can see, the bulk of the code has to do with formatting the output so that it looks nice on the screen. The output sections print the bit count and then separate the device and key codes so that they're easy to see. In the event an odd bit count is received (it has never happened to me), the program handles this in the **other** section of the **case** statement. At the end of the loop, a short delay is inserted to prevent overrunning the transmit buffer.

The hardware for this program is a no-brainer. **Figure 2** shows the PNA4602M decoder that we've used in the past; the addition of the 2.2K resistor is to limit the amount of current flowing through the Propeller's I/O pin protection diodes (these come into play with the decoder output being 5V). **Figure 3** shows the circuit connected on a Propeller Demo Board and, finally, **Figure 4** shows the output to a terminal window (using PST). The first two lines represent the channel up and down buttons on my TV/DVD multi-function remote; the last two lines represent the volume up and down buttons.

■ FIGURE 4. SIRCS Sniffer Test Setup.

Experiment with your remotes. I'm sure you'll find — as I have — that even within the same brand (using SIRCS) various models will have their own device code, even if the key code matches. The up-side of this is that we can design a program to respond to a very specific brand of remote.

TRANSMITTING SIRCS WITH THE PROPELLER

I got started with SIRCS transmission when I needed a way to control my Sony DSLR to create time-lapse videos. What was somewhat challenging using the SX becomes pretty easy in the Propeller, especially when we take advantage of one of the counters to handle the IR LED modulation frequency.

Figure 5 shows how to connect an IR LED to the Propeller; note that we're modulating and controlling from the cathode end, with the anode being tied to 3.3V. You may remember that in the SX we used two pins: one for modulation; one for control. So, why just one pin when using the Propeller? What changed?

In the Propeller's architecture, any element that can make an output pin go high is OR'd together within the cog before being OR'd with other cog signals and routed to the final output (refer to the Propeller block diagram in the user manual). Within every cog there are four elements that can make an output pin go high: the output register, counter A, counter B, and the video generator.

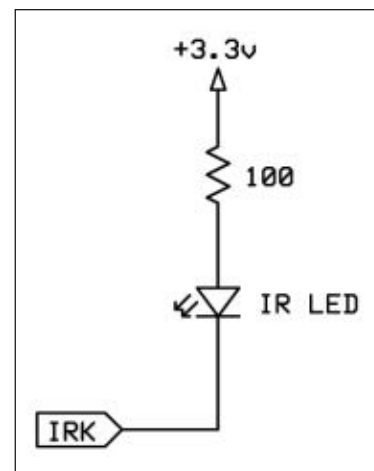
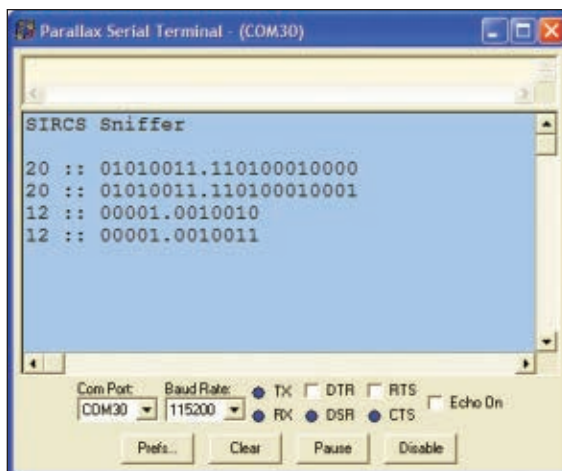
What this means for us, then, is that we can modulate the LED by directing a counter set to NCO mode to the cathode pin, and disable that signal when desired by writing a 1 to the same pin. Doing this will hold the cathode high and the LED will turn off. When we take that pin low, the modulation signal from the counter can pass through to the LED. Pretty neat, huh?

Before jumping into the code, there is one small "bit" of business. When using a counter in NCO mode, we need to set the FRQx register to provide the desired output frequency. The formula for the proper FRQx setting in NCO mode is:

$$\text{FRQx} = \text{Hz} \times 2^{32} / \text{System Frequency}$$

As I tend to run my Propeller projects at 80 MHz, I've created constant values for popular modulation frequencies used with IR remotes.

Okay, then, let's do it. On entry, we need to make the IR cathode pin an output and high to turn it off. We then set up a counter to provide the



■ FIGURE 5. SIRCS Transmitter Circuit.

modulation signal.

```
txsircs      or      outa, ircath
              or      dira, ircath
              mov      frqa, modfreq
              mov      ctra, modctrl

waitcmd      rdlong   frcount, fcpntr wz
              if_z     jmp      #waitcmd
              rdlong   bitcount, bcpntr
              rdlong   code, irpntr
```

Transmission is initiated by writing to shared hub variables that hold the code to send, the number of bits to use, and the number of frames to transmit. At **waitcmd**, the number of SIRCS frames is read from the hub, and when greater than zero we drop through and read the bit count and the device/key code to send. The next step is to send it.

```
startframe   mov      bcount, txbitcount
              mov      testmask, #1
              mov      frametimer, MS_45
              add      frametimer, cnt

txstart      mov      bittimer, BIT_START
              call     #txbit
```

Since we'll typically send more than one frame, we make a copy of *bitcount* and then create a mask that is set up for bit zero. The frame timing is set by loading the number of system counter ticks in 45 ms into a variable called *frametimer* and then adding the system counter to that — we'll use this value with **waitcnt** after all the bits have been transmitted to pad the frame to the correct duration.

The first element of an SIRCS frame is the 2.4 ms start bit. To handle this, we load the variable *bittimer* with the start bit timing and then call a subroutine called **txbit**. In previous projects, our PASM code didn't need subroutines but they are available, and this program is a

good place to use them. Here's that code:

```
txbit      add      bittimer, cnt
           andn     outa, ircath
           waitcnt  bittimer, #0
           or       outa, ircath

txpad      mov      bittimer, BIT_PAD
           add      bittimer, cnt
           waitcnt  bittimer, #0

txbit_ret  ret
```

There's really nothing to this. We synchronize *bittimer* to the system counter (*cnt*), enable the LED by taking the cathode control pin low, and then wait for the timer to expire. When it does, the LED is turned off and at *txpad* we insert the 0.6 ms pad between bits.

Before we leave this, there is one important note. You can see that the last line of the subroutine has a special label: *txbit_ret*. The nature of the Propeller's architecture and assembler requires that the final line of a PASM subroutine is labeled with a subroutine name that is appended with *_ret*. So, what about those advanced programs where we create a subroutine with two or more entry points? No problem! We can give the *ret* line multiple labels like this:

```
name1_ret
name2_ret      ret
```

Note that the *ret* instruction is on the last line.

Okay, with the start bit out of the way we can transmit the device/key code. This is handled by a simple loop that is controlled using *bcount* (the copy, so it's okay to modify).

```
txcmd      test     txcode, mask    wz
           if_z      mov      bittimer, BIT_0
           if_nz     mov      bittimer, BIT_1
           call      #txbit
           shl       mask, #1

checkdone  djnz     bcount, #txcmd
```

One of the things I really like about PASM is conditional statements. The first line at *txcmd* uses *test* to determine the state of the current bit. You'll probably remember that *test* works just like *and* except that it doesn't modify the destination variable (*txcode* in this case). The result of *test* is written to the Z-flag. When the bit is zero, the Z-flag will be true; when the bit is clear, the Z-flag will be false.

The next two lines take care of setting *bittimer* to the

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appropriate value, using the conditional statements. The condition clause, **if_z**, will load *bittimer* with the timing for a zero bit when the bit is, in fact, zero. You may be wondering what happens to this line when the bit is one. The condition clause forces the line to effectively become a **nop** — it does nothing. No harm, no foul; easy-peezy.

With the timing in place, we call *txbit*, then shift the mask one position to the left for the next bit and, finally, update the bit count. If there are more bits to send, the program jumps back to *txcmd*. Once the bits are all sent, we drop through to *waitframe* where we hold the program until the 45 ms frame timing expires.

```
waitframe      waitcnt frame-
timer, #0

                djnz
frames, #startframe

txdone         wrlong  ZERO,
fcptr          jmp
#waitcmd
```

The last step in the process is writing a zero back to the hub where the frames count is stored; this serves to alert the caller that the transmission is finished. With the hub updated, we go back to *waitcmd* and stay there until called on to send another SIRCS device/key code frame.

And there you have it — receiving and sending Sony SIRCS codes with the Propeller. In the download package on the *Nuts & Volts* website (www.nutsvolts.com), you'll find a little demo that changes channels on my TV. To use this, you'll probably want to run the "sniffer" program first to verify the channel up and down keys.

Want to have a little fun? Toss an IR LED onto a demo board, program it to randomly change channels or turn off the TV, and then discreetly place the contraption when your friend won't notice or pay attention to it. (Hey, who says those of us who love electronics aren't up for a tech-based gag from time-to-time?)

Until next time, have fun, and keep spinning and winning with the Propeller. **NV**

JON WILLIAMS
jwilliams@efx-tek.com

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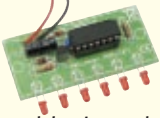
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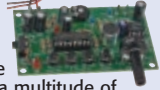
This little kit flashes six high intensity LEDs sequentially in order. Just like the K80302 to the right does with incandescent lights. Makes a great mini attention getter for signs, model trains, and even RC cars. Runs on a standard 9V battery.



MK173 Mini LED Light Chaser Kit \$13.95

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This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.



MK171 Voice Changer Kit \$14.95

Laser Trip Senser Alarm

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ECG1C ECG Heart Monitor Kit \$44.95

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K8032 4-Channel Running Light Kit \$38.95

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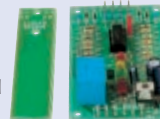
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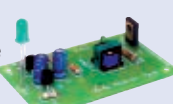
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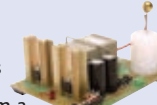
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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ Neon Lamps and LEDs
- ✓ DC Power Distribution
- ✓ PC Board Current Capacity

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions.

Send all questions and comments to:

Q&A@nutsvolts.com

HIGH CURRENT LED DRIVER

Q I have a request, having been an avid reader for many years now. I recently purchased an IR LED laser diode on eBay. This one gives about 30 watts of power, hopefully giving me an opportunity to cut various plastics on my CNC. The laser uses about 2.2 volts but only kicks in at 10A. At 20A, the laser will be at its best, but this maximum is not critical. I would like to use the laser at different power levels. I need a good

current source to power the laser diode. I was thinking about a 5V PC power supply as a start, but still need a good current source. I was only able to find low current circuits on the Internet. Do you have a good schematic I can use?

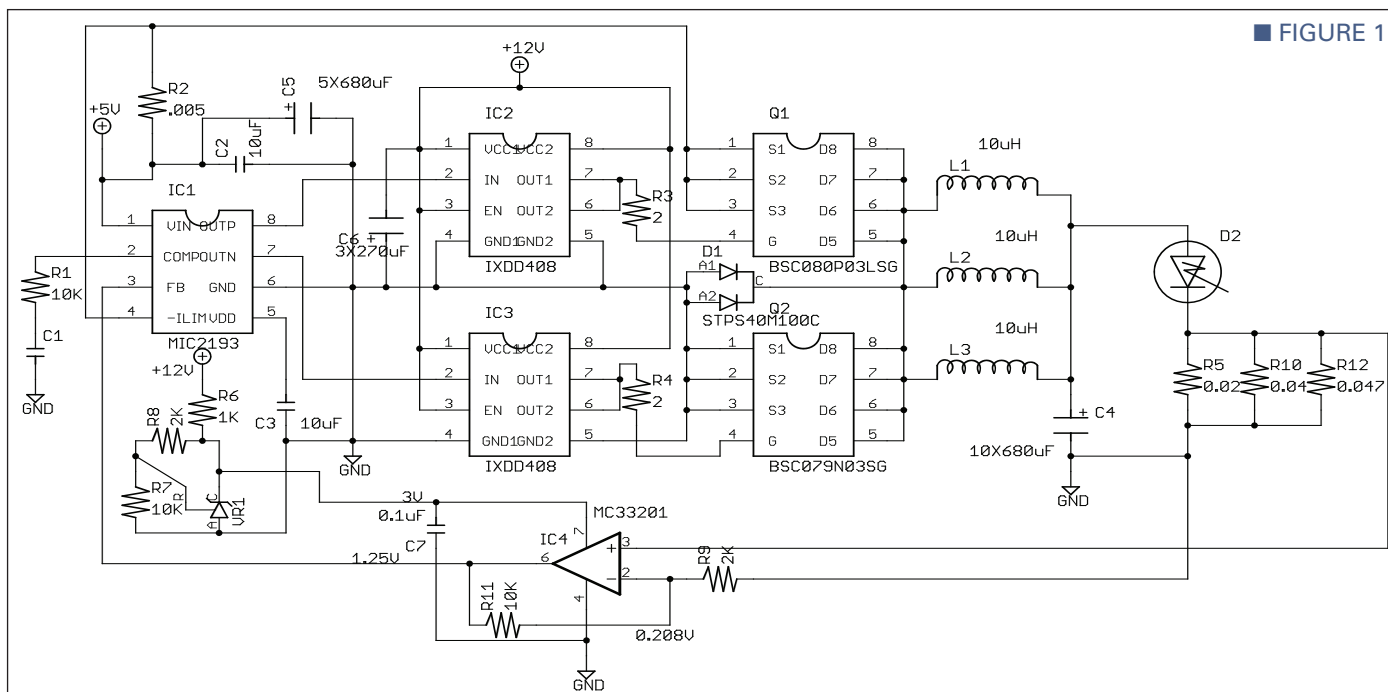
— Ronald Wijngaarde

A I designed the circuit of **Figure 1** intending to have all hand-solderable parts even though some are surface-mount, but the switching transistors (Q1, Q2) can not be hand-soldered. It seems that all the good parts nowadays are surface-mount

and you need an IR oven or vapor phase system.

IC1 is a current mode controller operating at 400 kHz. It is designed to drive a P type and N type MOSFET to maximize output, but the drive is less than one amp at five volts; I figured that was not enough for the high current output FETs, so I added the drivers, IC2 and IC3. The driver ICs operate from +12V in order to keep the speed up and to provide more drive to the power FETs.

At 20 amps output, the power dissipation in Q2 will be 3.2 watts, worst case. The thermal resistance



■ FIGURE 1

with a six square cm heatsink area is 45 deg C/watt, so the junction temperature is 144 deg C. This is too close to the 150 deg C maximum, so you will want to blow some air on it or provide more heatsink.

Feedback is from a current-sensing resistor in series with the laser diode, so the output is a current source. I could have run the feedback directly to pin 3 of IC1 but that would require 1.25 volts across the resistor at 20 amps (or 25 watts down the drain). I added IC4 which will have 1.25 volts output with 0.208 volts input. Now the power in the sense resistor is about four watts. In order to vary the current from 10 amps to 20 amps, I doubled the sense resistor value and put a pot in parallel. Now the power in the sense resistor is eight watts at 20 amps.

I simulated part of the circuit — enough to see that the inductor current is continuous and does not exceed 21 amps — so R2 calculates to be .0052 ohms. R2 = .005 is close enough. Although my simulation indicated low ripple current, I used multiple parallel output and input capacitors to reduce ESR and increase ripple current capability. IC4 operates from three volts because the feedback input of IC1 has a +3 volts max limit. The gain of IC4 may cause the loop to oscillate. If it does, choose C1 such that its reactance is 10K at a frequency one or two octaves below the oscillating frequency. **Figure 2** is the parts list.

While researching for this answer, I found the LTM4600 which is surface-mount and totally not hand-solderable. The unit is rated 10 amps and can be paralleled; see **Figure 3**. The switch transistor and inductor are in the device so all that is needed externally are the filter caps. The **Figure 3** schematic is from the

HIGH CURRENT LED DRIVER PARTS LIST

PART	DESCRIPTION	PKG	PART #	SUPPLIER
R1, R7, R11	10K, 1%, 1/8W	1206	290-10K-RC	MOUSER
R2	.005 OHMS, 5%, 1W	OARS	66-OARS1R005JLF	MOUSER
R3, R4	2 OHMS, 1%, 1/4W	1206	660-SR732BTTE2R00F	MOUSER
R5	0.02 OHMS, 1%, 2W	2816	71-WSL2816-0.02-E3	MOUSER
R6	1K, 1%, 1/8W	1206	290-1.0K-RC	MOUSER
R8, R9	2K, 1%, 1/8W	1206	290-2.0K-RC	MOUSER
R10	0.04 OHMS, 1%, 2W	2816	71-WSL2816-0.04-E3	MOUSER
R12	0.047 OHMS, 1%, 2W	2816	71-WSL2816-0.047-E3	MOUSER
C1	SEE TEXT	1206	140-CC502BxxxK-RC	MOUSER
C2, C3	10 μ F, 10%, CERAMIC	1206	80-C1206X106K4RACTU	MOUSER
C4 (QTY=5)	680 μ F, 6.3V, 20%	RADIAL	661-PSA6.3VB680M	MOUSER
C5 (QTY=3)	680 μ F, 6.3V, 20%	RADIAL	661-PSA6.3VB680M	MOUSER
C6 (QTY=3)	270 μ F, 16V, 20%	RADIAL	75-94SP277X0016FBP	MOUSER
C7	0.1 μ F, 50V, 10%	1206	140-CC502B104K-RC	MOUSER
D1	20A, 100V, SCHOTTKEY	TO220	511-STPS40M100C	MOUSER
IC1	MIC2193 IMODE	SOIC-8	576-1545-1-ND	DIGI-KEY
IC2, IC3	FET DRIVER, 8 AMP	SOIC-8	IXDD408SI-ND	DIGI-KEY
IC4	OP-AMP, RAIL/RAIL	SOIC-8	863-MC33201DG	MOUSER
Q1	P-FET, 30V, 30A, 8 mOHM	TDSON-8	726-BSC080P03LSG	MOUSER
Q2	N-FET, 30V, 40A, 8 mOHM	TDSON-8	726-BSC079N03SG	MOUSER
L1, L2, L3	10 μ H, 11A,	TOROID	542-2200HT-100V-RC	MOUSER
VR1	TL431 SHUNT REG.	TO-92	512-TL431ACZ	MOUSER

■ FIGURE 2

datasheet; I only changed the feedback to use a current sense resistor. The internal reference voltage is 0.6 volts, so that is low enough that the power in the sense resistor is 12 watts at 20 amps. If the output is to be variable, a feedback IC like MC33201 would make sense.

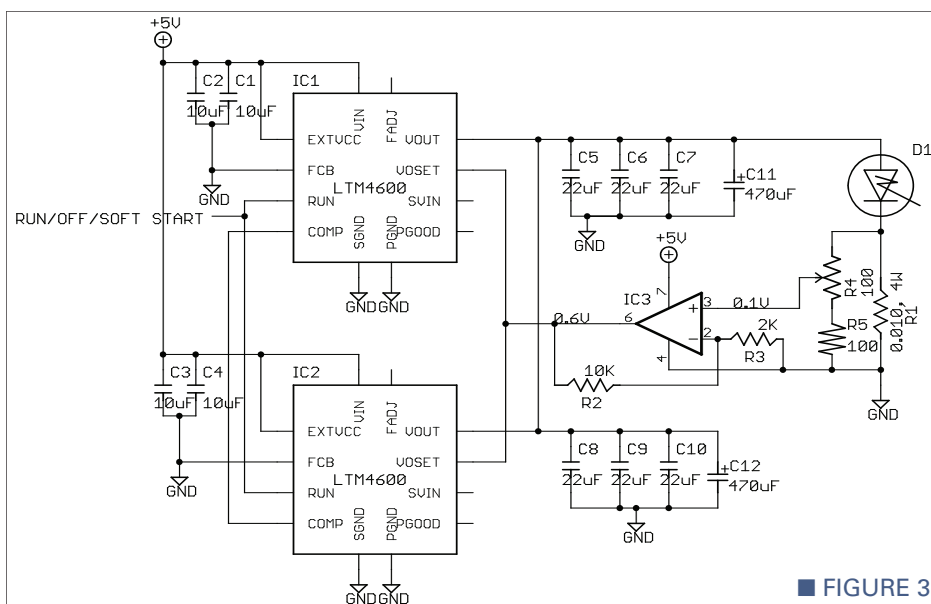
NEON LAMPS AND LEDS

Q I always enjoy reading your column; it is the first thing I turn to when I get N&V. I've been meaning to ask the following questions for some time so I

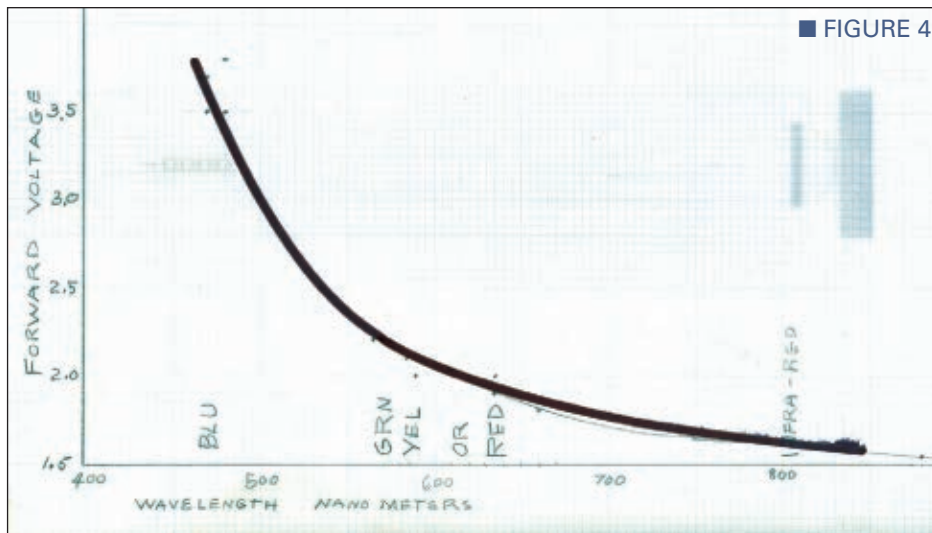
can make use of some stuff I've accumulated over the years.

1. How can I determine the value of the series resistor necessary to use an unidentified neon lamp at 120 VAC? I am primarily concerned about unbased lamps, but I have also wondered if any with bases already have a resistor. Is there any rule about which — if any — neon lamps with bases have an internal resistor?

2. I have a similar question about LEDs. How can I determine the value of the series resistor necessary to use an unidentified LED in a low voltage



■ FIGURE 3



■ FIGURE 4

and for Q1 use TIP42C. D1 and the TL431 have to be turned around; connect the cathode and control of VR1 to ground and the anode to R2.

SHORTEN RUN TIME, KEEP CYCLE TIME

Q I have a half dozen small (<3A, 110V) sump pumps that run on timers. The problem is the minimum run time is one hour. During dry times, 15 to 30 minutes every three hours is enough. I want to run them every three hours even if only for a few minutes (gallons) because I use the discharge to keep seedlings damp. How can I change the run time to 15 or 30 minutes while maintaining the three hour cycle time? Maybe a float valve/switch or a minute timer between the timer and pump?

— Ed Bixby

A Thirty minutes is too long for a 555 time delay, so I designed a counter circuit; see **Figure 5**. The components D1, D2, C2, C3, and R2 provide 12 VDC for the circuit. IC5A oscillates at 0.1 Hz so the counter has to count 90 pulses for 15 minutes, and 180 pulses for 30 minutes. The count is decoded by IC4A and B, and the time is selected by SW1. The remaining sections of IC5 are paralleled to give more drive to the solid-state relay, RLY1, which turns on the triac. Any six amp, 600 volt triac should work; the part number on the schematic is supplied by Digi-Key.

DC circuit?

Thanks for your help. Many years ago, T. J. Byers helped me fix my uncle's welder that he couldn't get anyone else to work on.

— Ed Palazzo

A Thanks for the kind words. Most neon lamps turn on at 90 VDC and you should calculate the resistor for a current of 0.3 mA. If the lamp is too dim you can reduce the resistance, but connecting a neon lamp to 120 volts AC without a resistor will destroy it. If you don't know if there is a resistor, assume there is none; there is no standard or rule that I know of. If the lamp has a base and is numbered — like NE51 — you can look it up.

The forward voltage of an LED depends on its color. You can use a five volt DC source and 1K resistor to determine the color and also measure the forward voltage. Most T-1 3/4 LEDs are rated 20 mA max. If you

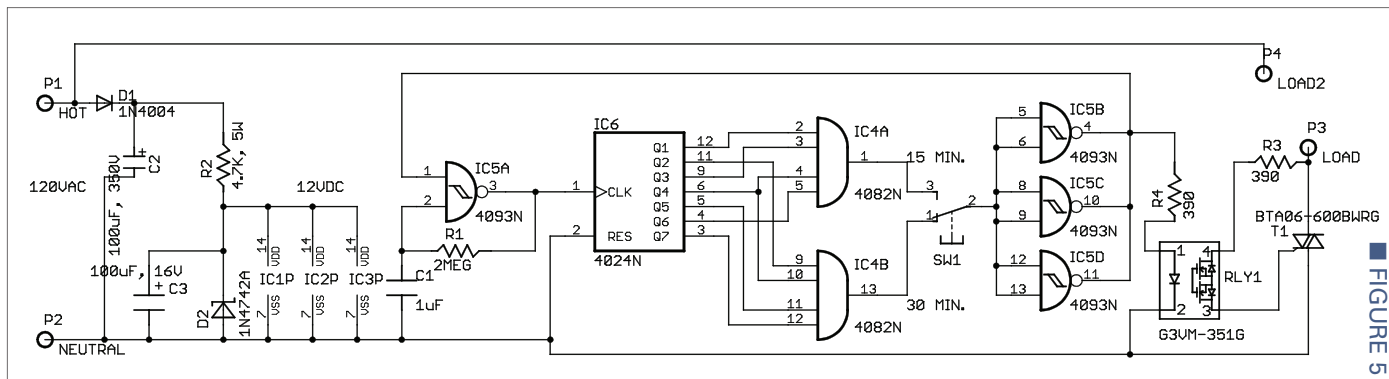
know the color, you can refer to **Figure 4** which is a curve of forward voltage versus wavelength which I compiled for my own use several years ago.

GENERATOR VOLTAGE REGULATOR

Q The modified generator voltage regulator in the October issue looks like just what I need for my old Massey Ferguson tractor, except it is positive earth. Could you publish a similar circuit for a positive earth vehicle?

— Dave Loten

A The easy way to change from negative ground to positive ground is to change the NPN transistors to PNP and vice versa. In **Figure A** of the October issue: for Q3 and Q4, use 2N2222; for Q2, use 2N2907;



■ FIGURE 5

PC BOARD CURRENT CAPACITY

Q Do you know of any tables dealing with DC current flow in a PCB? Let's say the PCB has one ounce of copper and I want to run traces for power, relays, etc. What is the required trace width per one amp?

For example, a relay may carry 5A of current, but the PCB trace shouldn't melt on slight overload, or another example for my PoE design: RJ45 jack has this weird footprint. Is there enough room for 500 mA traces or do I need a PCB manufacturer who can provide two ounce copper boards? I guess some robot builder may know; I bet they smell smoke often.

— Dusan

A No, I have not seen that kind of table, but my wire tables list fusing current and you would want to be well below that. For one amp, set the fusing current at five amps. The wire size is #34 which has a cross-section of 3×10^{-5} square inches. I think the fusing current for a PC run on 1/16th FR4 will be higher than for a round wire, so there will be some additional safety factors. The width of a one mil PC run for 3×10^{-5} sq in is 30 mils. I expect that the extension to higher currents would be linear. Two ounce copper would not have as many additional safety factors because the width is less, but the same analysis will apply.

DC POWER DISTRIBUTION

Q I want to add network control and monitoring to existing electric door locks. The locks are powered from a 24 VDC switching power supply which can power up to six doors in the same area, so there are several of these power supplies in different areas.

The network micro with opto

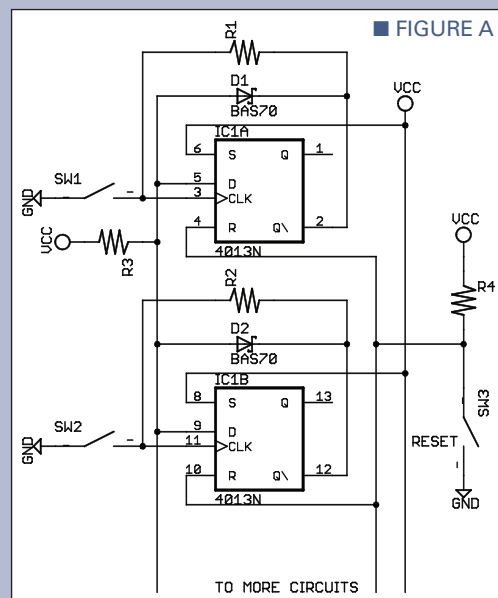
MAILBAG

Dear Russell:

Re: Game Show Lockout, October Issue, page 26. I have attached a schematic (Figure A) of a more flexible and simpler Game Show Lockout circuit. All the resistors could be 4.7K. The diodes should probably be Schottky to keep the voltage drop down if ACT or HCT devices are used. The common data line can be used to drive a speaker circuit. I have not tried, but it looks like it will work for a large number of inputs. Resetting the circuit causes all Qbar outputs to go high. As soon as one of the input switches is pressed, the associated Qbar will go low bringing down the common D inputs so any other switch presses are ignored. Since the switch on the first is driven by its Qbar, it is now pulled to ground and cannot cause the FF to toggle again. Hope you like the circuit and find it helpful.

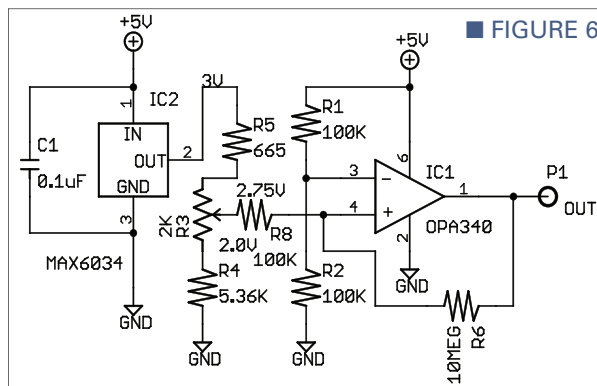
— Larry Cicchinelli

Response: Thanks for sharing your circuit, Larry; it is real simple and innovative.



inputs and relay outputs draws under one amp at 12 VDC with all the relays on. I can power it from the existing 24 VDC switching power supplies, but I also want backup power for the micros (the building doesn't have generator backup power). I'm thinking Power over Ethernet (PoE) to eliminate additional wiring labor, and I don't want batteries for backup due to lack of maintenance.

The question is: Is it okay to connect the PoE ground to the existing power supply ground? The existing power supply is very close to the system, while the PoE power comes from hundreds of feet away over thin



24 gauge Cat-6 wires. Won't there be a voltage difference at the two grounds?

I remember I saw somewhere using 100 ohm resistors on RS-485 grounds for that reason (RS-485 can run thousands of feet on thin wires).

— Dusan

PARTS LIST

PART	DESCRIPTION	PKG	PART #
IC1	RAIL/RAIL OP-AMP, LOW POWER	SOT23	595-OPA340NA/250
IC2	PRECISION 3 VOLT REFERENCE	SC70	700-MAX6034BEXR30T
R1, R2, R8	100K, 1%, 1/8W	1206	290-100K-RC
R3	2K POT, MULTITURN		81-PVG5A202C01R00
R4	5.36K, 1%, 1/8W	1206	290-5.36K-RC
R5	665 OHMS, 1%, 1/8W	1206	290-665-RC
R6	10 MEG, 5%, 1/8W	1206	263-1.0M-RC
C1	0.1 µF, 50V, 10%	1206	140-CC502B104K-RC



A If the building has no generator backup, where does the PoE come from? Your power usage is under 12 watts so it meets the 802.3af system requirements. The Ethernet voltage is 48 volts DC so you will need a 48 to

12 volt converter. I can't answer the question of whether you can connect the two grounds without knowing more about the system. If you connect them and it doesn't blow a fuse, you should be okay power wise, but I don't know what might happen

to any data being sent.

DELTA V DETECTOR

Q I am trying to figure out a reasonably simple circuit which will detect when a five volt battery drops in value. I would like to see a circuit to detect a drop as small as .08 volts, and give a high or low to indicate this.

— Chuck Irwin

A The circuit of **Figure 6** is a comparator with positive feedback so it will switch cleanly. The hysteresis is 30 millivolts which means the voltage will have to recover by that amount before the output switches back. The output will be low initially and will switch high when the voltage falls below the set point. The offset voltage of IC1 is 8 millivolts, so that is the uncertainty in the set point. R3 should be a multi-turn pot in order to set the voltage accurately. The junction of R8 and R6 is the place to measure the set point voltage when the output is low. The **Parts List** is all Mouser part numbers and are surface-mount devices, but thru hole parts are available.

IC1 and IC2 both have a maximum voltage rating of 5.5 VDC so if you want to operate at 12 volts, use MC33201 for IC1 and LM4040 with a series 10K resistor for IC2. R2 is changed to 26.1K also. **NV**



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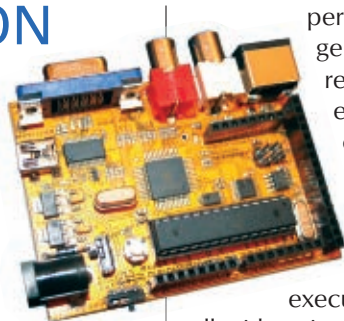
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The real power of the Chameleon is based on its dual processor design. The Chameleon comes in two flavors: the AVR eight-bit and PIC 16-bit versions. The AVR version uses the Atmel AVR328P eight-bit processor while the PIC version uses the Microchip PIC24 16-bit as the main master processor (client), along with the Parallax multicore Propeller chip as the media processor (server). Thus, instead of taxing a single processor system to do everything, the Chameleon offloads all the heavy lifting to the multicore Propeller chip which has eight processing cores to

perform tasks such as generate video, audio, read keyboards and mice, etc. The AVR/PIC sends commands to the Propeller chip over a high speed SPI interface to command the Propeller to

execute various operations all with a simple API that usually consists of a few lines of code to perform any task. Thus, the AVR/PIC programming is very easy and with simple APIs, you can develop very complex and rich media applications that leverage the Propeller chip's media rendering abilities and huge software library. For example, you can generate TV signals, VGA, read keyboards and mice with a few lines of code.

Arduino Compatibility

Both the AVR and PIC versions are designed to have Arduino I/O header compatibility as much as possible, but the AVR version is additionally 100% software compatible and the Arduino tool can be used to develop software for the AVR version (as well as AVRStudio). The PIC version works with MPLab, as well as a stand-alone "Arduino-like" tool chain that relies on a bootloader. Thus, both systems have "bootloader" hosted development where all you need is a Text editor and a USB port — no programming tools required.

Two Systems in One

The Chameleon is both a complete AVR/PIC application development board, as well as Propeller development board. Both processors can be independently programmed and used. Additionally, the AVR/PIC and Propeller both have

their own digital I/Os, so theoretically you can run two applications on the Chameleon and use it that way or use the processors together over the SPI link. Moreover, the Propeller sub-system is compatible with most Propeller development boards and the HYDRA™ system, so the Chameleon will run most of those applications with very little or no modification.

Chameleon Software and Hacking Support

There is a complete Basic programming language for the Chameleon, so you can code on the PC with a simple editor, compile, and download to the Chameleon. Thus, you can choose from C/C++, assembly language, or Basic to program the Chameleon. The Chameleon also has a "break away" experimentation protoboard built into the PCB. You can solder directly onto it, or place the mini solderless breadboard that comes with the Chameleon onto the area with two-sided tape. If you don't want the experimenter board, you simply "break" it away and snap it off.

Product Package Includes:

- Chameleon main board (AVR or PIC processor) system pre-loaded with appropriate bootloader, so you can program using the USB serial port and included tools.
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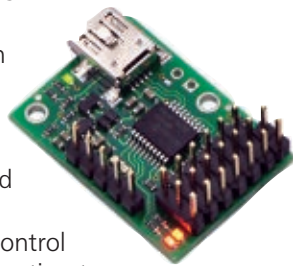
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MICRO MAESTRO SIX-CHANNEL USB SERVO CONTROLLER

Pololu announces the release of the Micro Maestro, the first of its new line of USB serial servo controllers. In addition to a TTL serial interface, this tiny board incorporates native USB control for easy connection to a PC and programmability via a simple scripting language for self-contained, host-controller free applications. The Micro Maestro's extremely accurate, 0.25 μ s resolution servo pulses have a jitter of less than 200 ns, making this servo controller well-suited for high precision applications; individual speed and acceleration control for each channel allow for smooth, seamless movements. Units can be daisy-chained with additional Pololu servo and motor controllers on a single serial line. The Micro Maestro's six channels can be used as general-purpose digital outputs and analog inputs, providing an easy way to read sensors and control peripherals directly from a PC over USB. These analog inputs also enable creation of self-contained animatronic displays that respond to external stimuli.

A free configuration and control program (Windows XP, Vista, and 7 compatible) makes it simple to configure and test the board, create sequences of servo movements for animatronics or walking robots, and write, step through, and run scripts



stored in the servo controller. A Linux version of the software is available, and the Maestro is fully Linux compatible. The unit price is \$24.95 for the fully assembled version (item #1350) and \$23.95 for the partial kit (item #1351).

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supplies a +5 phantom voltage to unbalanced microphones such as the TDL® Model 818 and a +48 phantom voltage to balanced microphones such as the Behringer ECM-8000 and Dayton EMM-6. The 411 has a very low output noise because the power supply (including the +48V DC-to-DC converter) is housed in its own cast aluminum box inside the outer cast aluminum enclosure. All the input and output connectors are located on the rear side of the enclosure. Operation is from a +24 VDC wall wart supply.

INPUT: Designed for microphones needing an input impedance of 150 to 600 ohms. Female RCA for an unbalanced electret capacitor mic (+5V phantom). Female XLR for a balanced electret capacitor mic (+48V phantom). Note: Two mics CANNOT be connected at the same time.

GAIN: Zero dB (unity gain) to 40 dB, 10 to 50dB, or 20 to 60 dB in 4 dB steps using an 11-position rotary switch. Gain range is set by removing the top cover plate and changing a jumper position.

RESPONSE: Flat (± 0.5 dB) 10 Hz to at least 50 kHz.

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POWER: Operation from a 24 VDC wall power supply (furnished). Red LED indicates power on. (No

Continued on page 77



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GARAGE PARKING ASSISTANT

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BY CHRIS SAVAGE

When we moved into our new house, we upgraded to a bigger garage than we had before. My wife now parks in the garage — something she did not do before. Her main problem is not knowing how far forward to pull the car in to leave enough room in front of and behind the car. Instead of the traditional tennis ball hanging from a string, I decided to take a more hobbyist approach to the problem at the risk of negatively impacting tennis ball sales.

Free of Tennis Balls

The Garage Parking Assistant makes it easy to park in the garage by signaling you with a traffic-light style display of when to pull in (GREEN), slow down (YELLOW), and stop (RED). If you pull in too far, the red LED blinks to let you know you need to back up a bit.

Although this type of project has been done several

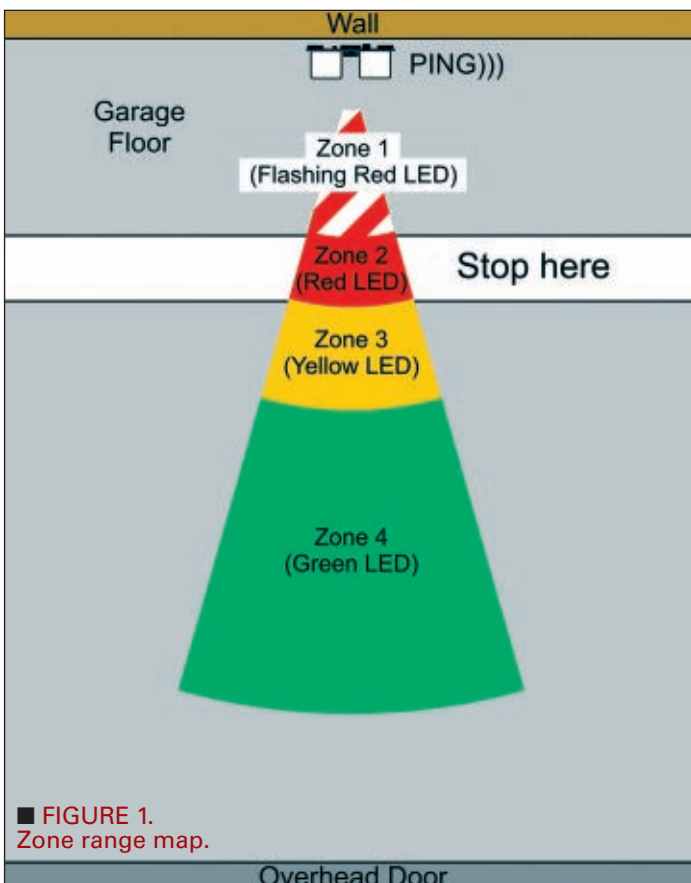
ways, I wanted to take my own approach and simplify the code and hardware while making it easy to adjust and personalize for your own use. By default, all measurements are in inches, although you could easily use centimeters since that information is available as well. All you would need to do is replace all instances of inches in the main loop with cm. If you're using a laptop to debug distance, you will need to uncomment the debug line that displays cm and comment the one that displays inches. Finally, you will need to change the constants for each zone since they are specified in inches.

The range of the PING))) sensor we'll be using is ~0.8 inches up to 3.3 yards and is split up into four zones labeled Zone1 through Zone4. **Figure 1** shows a map of the zones. The values in the constants section for each zone are inches from the sensor/wall.

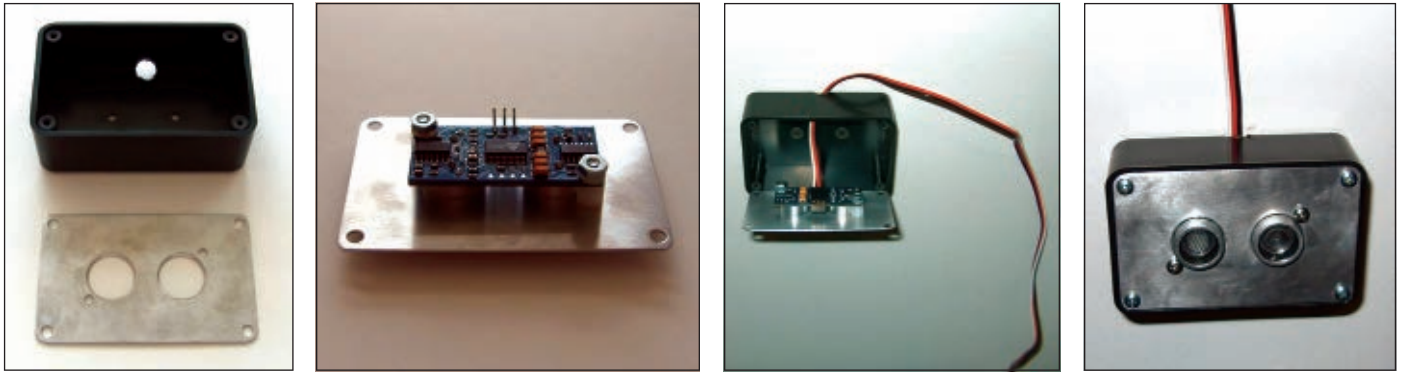
Zone1 (Striped) is closest to the sensor/wall and indicates the area you don't want to occupy. When you are in this zone, the red LED will flash on/off to indicate you are too close. In our garage, this area is big since we want to have plenty of room in front of the car. The default setting for Zone1 is 36 inches (three feet).

Zone2 (Red) is the area where you want the front of the car to stop in. This will be between the Zone1 and Zone2 settings. When you are in this zone, the red LED will be solid telling you to stop since you are in the desired zone. You don't want to make this zone too small since you will need to stop within it without having to keep adjusting. You also don't want to make it too big. The default setting is 46 inches, giving you a 12 inch buffer. When you set this, you want to make sure it is far enough away from the wall as well as have enough clearance from the garage door.

Zone3 (Yellow) is the area in which you want to slow down and be prepared to stop. When you are in this zone, the yellow LED will be on letting you know



■ FIGURE 1.
Zone range map.



■ FIGURE 2A-2D. Remote sensor construction.

you are approaching the red zone. The default setting for this zone is 80 inches. Adjust accordingly for your garage.

Zone4 (Green) is the area from where the PING))) sensor first detects the car until you enter the yellow zone. When you are in this zone, the green LED will be on. By default, this value should be the maximum range detected by your PING))) when no car is in the garage. This is the zone where you can pull in normally.

Protecting Your Assets

To keep the PING))) well protected against environmental effects or someone or something accidentally brushing against it, I bought a small enclosure from RadioShack to house the module. The enclosure is shown milled in **Figure 2A**. In **Figure 2B**, the PING))) sensor has been mounted to the cover lid using nylon spacers. This prevents damaging and shorting traces on the sensor which can happen when using metal screws, nuts, or standoffs. Notice also in **Figure 2B** that the header pins have been bent back slightly to allow the cable to connect inside the enclosure. I mounted the unit to the garage wall using sheetrock screws (**Figure 2C**). **Figure 2D** shows the completed assembly.

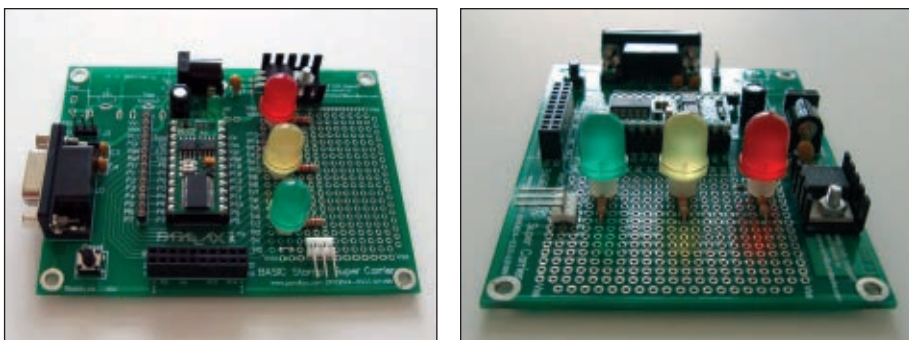
The ideal position of the enclosure is such that the PING))) can easily see the front of the car. In our case, this meant lining the sensor up with the license plate. Any higher or lower and the curvature of the car would cause reflection away from the sensor.

Taking Control

This project was built on a Super Carrier Board. This inexpensive project board is ideal for one-off BASIC Stamp finished projects because it contains most of what the Board of Education does — except that it is intended for soldering and runs the BASIC Stamp Module from the on-board regulator allowing a wider range of supply voltages. The enclosures that the PING))) and Super Carrier Board were mounted in were just plastic prototyping units I had on hand. You can refer to the **Bill of Materials** for sources I used, although any enclosure which will fit these boards in will work. Optionally, you can mount both the Super Carrier Board and the PING))) right to the wall, although you may want to cut the power LED trace on the Super Carrier Board to prevent it from giving you a false GO signal. You could also remove the green power LED from the board by desoldering it.

As you can see in **Figure 3A**, I used 10 mm LEDs since they're much easier to see. The header for the PING))) sensor is mounted at the bottom, aiming down. Please note that the **schematic** shows there are 220 ohm current-limiting resistors for the green/yellow LEDs, while the red has a 470 ohm resistor. This is because the red LED requires less current to obtain the same light intensity. To make the LEDs uniform, I used these values. Different LEDs have different forward voltages and currents, so you may need to adjust these values depending on the LEDs you use. Often, 220 ohm through 470 ohm resistors will work. You may also notice in **Figure 3B** that I used 1/4 inch plastic spacers to keep the LEDs at the same height

■ FIGURE 3A-3B. Main control board construction.



■ FIGURE 4. Installing the control board into the enclosure.





■ **FIGURE 5.** The face of the control enclosure after being milled.



■ **FIGURE 6.** The completed assembly mounted on the garage wall.



■ **FIGURE 7.** View of the entire Garage Parking Assistant.

from the PCB. This allows the LEDs to extend through the face of the enclosure. In **Figure 4**, the Super Carrier Board has been mounted inside the enclosure using standoffs. A hole was cut into the bottom of the enclosure for the sensor lead. **Figure 5** shows the holes cut into the face of the enclosure for the LEDs and **Figure 6** shows what the finished assembly looks like mounted to the

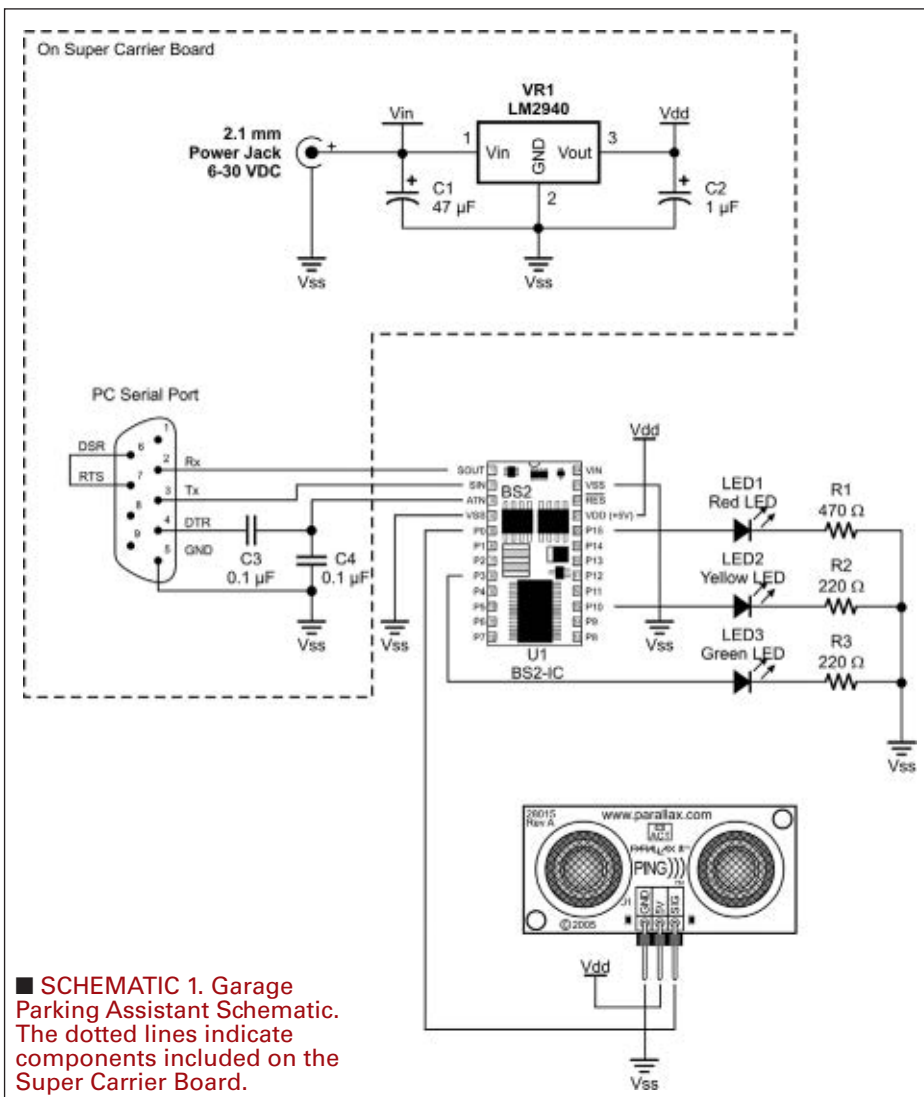
garage wall using sheet rock screws.

Hi-Tech Parking

Now that everything is assembled and mounted, we can make adjustments to the code as necessary. In **Figure 7**, you can see that power was obtained from a wall adapter plugged into an outlet in the garage. You can load the Garage Parking Assistant V1.0 code into the control board to get started. Now pulling into the garage is as easy as pulling up to a traffic light!

No Laptop? No Problem!

Since some readers may not have a laptop they can take out to the garage to help tune their Parking Assistant, we'll add a button that will allow us to set all of our zones without a PC. To do this, we'll first modify the face of the main enclosure to add a hole for the pushbutton switch as shown in **Figure 8A**. Then we will install the switch and wire as shown in **Figures 8B** and **8C**. We'll remove



■ **SCHEMATIC 1.** Garage Parking Assistant Schematic. The dotted lines indicate components included on the Super Carrier Board.

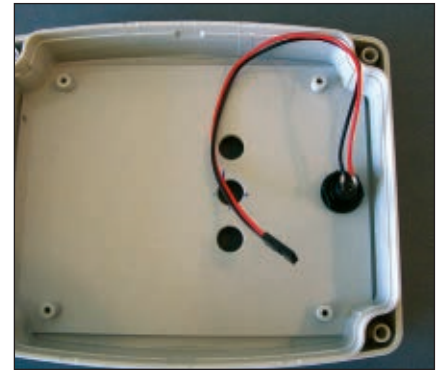
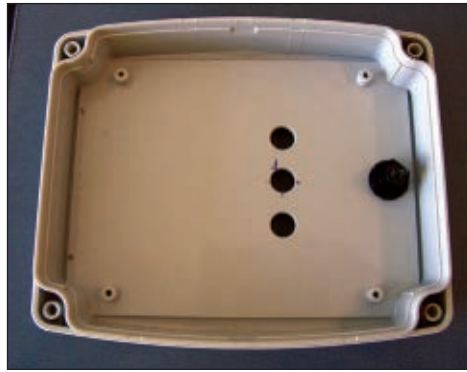
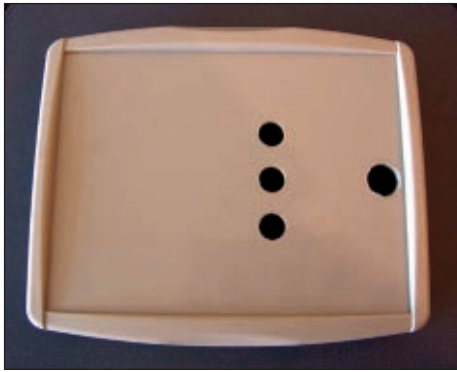
Resources

Project Page:
www.savagecircuits.com/garageparkingassistant/

Project Discussion:
<http://forums.savagecircuits.com/index.php?topic=40.0>

Parts Resources:
 Parallax
www.parallax.com

RadioShack
www.radioshack.com



■ FIGURES 8A-8C. Modifications necessary to enclosure face for pushbutton upgrade.

the control board and add a header for the switch wire to plug into. This can be done by adding an RA SIP header to the Super Carrier Board as shown in **Figure 9**. A 10K pull-up resistor was added, as was a 220 ohm series resistor.

Like Ringing a Doorbell

The source code was revised for the hardware changes and the new version (V1.1) can be loaded into the control board. Now you can set up zones by holding the button down for approximately two seconds until all three LEDs flash three times. At this point, the green LED starts flashing. The unit is waiting for the Zone4 setting. For most applications, this will be the maximum range of the sensor, so with nothing obstructing it you can simply press the button to set the maximum range. The sensor should not be able to see the garage door when closed. Once you press the button to set the Zone4 range, the yellow LED starts flashing waiting for you to set the Zone3 distance. Pull your car in to the point where you want to slow down. Once in position, press the button again. The Zone3 distance is now set and the red LED starts flashing. The unit is now waiting for Zone2 where you would normally stop. Pull your vehicle into position taking care to make sure you have exactly the clearance you want and press the button.

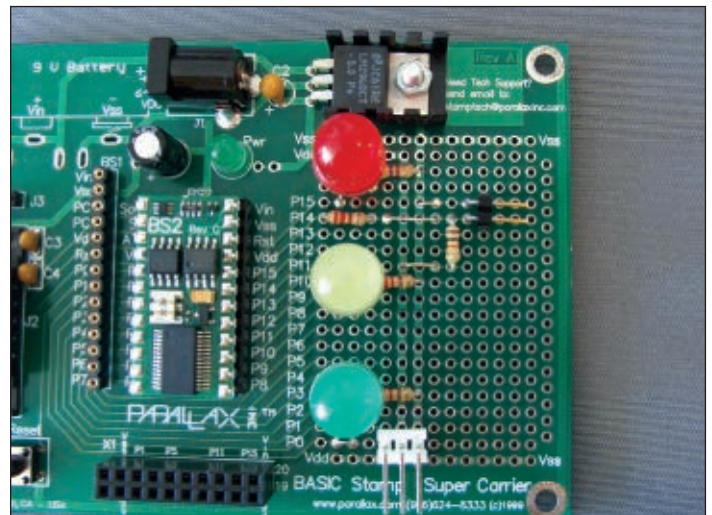
At this point, the Garage Parking Assistant is now ready to use the new values for parking. Zone1 is set automatically based on a buffer and minimum allowed distance of six inches. Pulling ahead of the red zone will

still cause the red LED to flash, warning you to back up.

Time to Build

All the information for this project can be found on the *Nuts & Volts* website at www.nutsvolts.com. Additional information, updates, and forum discussions can be found by visiting the project website located in the **resources** sidebar. Park it and have some fun! **NV**

■ FIGURE 9. Modifications necessary to Super Carrier Board for pushbutton upgrade.



Have Laptop Will Travel

While not required, a laptop is a great help in getting everything where you want because you can have it in the garage with you while the code is running and it is displaying the values so you can note these positions when setting your Zone constants. You will definitely want to know what the maximum value is that your PING))) sensor reports when no car is in the garage. You'll want to make sure that value is stable and set the Zone4 constant to this value.

BILL OF MATERIALS

ITEM	DESCRIPTION	SOURCE	PART #
U1	BASIC Stamp 2 Module	Parallax	BS2-IC
PCB	Super Carrier Board	Parallax	27130
LED1	10 mm Red LED	N/A	N/A
LED2	10 mm Yellow LED	N/A	N/A
LED3	10 mm Green LED	N/A	N/A
R1	470 ohms, 1/4W	Parallax	150-04710
R2, R3	220 ohms, 1/4W	Parallax	150-02210
PING)))	PING))) Sonar Rangefinder	Parallax	28015
ENC1	Project Enclosure (3x2x1")	RadioShack	270-1801
ENC2	Project Enclosure (5.1x3.1x1.5" Sealed)	PAC-TEC	OD45

Turn A Broken Laptop Into A Digital PICTURE FRAME

As a techie, I have accumulated a lot of hardware over the years and it pains me when I have to get rid of things that are old but still potentially useful. Such was the case with a laptop computer that had a broken hinge, broken Wi-Fi, and a broken sound system. It seemed destined for the scrap heap, even though it could still function as a portable computer.

Because of my desire to recycle, I decided to give the laptop a second life inside a shadow box picture frame that I could hang on the wall. I had wanted to buy a digital picture frame for a while, but this approach seemed much better because the frame would contain a complete, network-accessible computer that could run any applications I desired. My mind began racing with all the possibilities for a laptop picture frame (LTPF).

A Word Of Caution

I should caution you that a project like this is for those who feel comfortable tearing computers apart, and that have been successful in putting them back together into working order. A single careless step can send the laptop to the trash heap once and for all, so careful, deliberate work is definitely called for.

■ **PHOTO 1.** The finished LTPF in place in my living room.



I should also say this article describes the steps I went through to build a LTPF from a Gateway computer. The laptop you use will probably be different so you will need to adapt the information here accordingly. **Photo 1** shows my finished LTPF.

What You Will Need

1. A functioning laptop computer with a good LCD display, Wi-Fi capability (either built in or provided by a USB adapter or PCMCIA card), and power supply. The larger the display, the better (in my opinion).
2. A shadow box type picture frame large enough to contain the laptop hardware. I used a wooden shadow box I bought from Hobby Lobby. Its dimensions are: 21" W x 17" H x 2 3/8" D.
3. A mat to fit the frame with a cutout the size of the laptop's display. More on this shortly.
4. Two pieces of 1/4" MDF (medium density fiberboard) cut to fit into the frame.
5. Duct tape or other strong tape.
6. Quick set epoxy (the two-tube mixing kind).
7. A 3/8" wooden dowel for making standoffs/spacers.
8. An assortment of small wood screws and four 2" flat head machine screws, washers, and nuts.
9. A power switch. (In my case, I used a momentary contact SPST pushbutton switch.)
10. Some hookup wire.
11. Soldering iron, drill, saber saw, and other miscellaneous tools and supplies.

First Comes Destruction

I had to completely disassemble the laptop and get rid of all extraneous parts to squeeze the laptop circuitry and the LCD display into the shadow box I wanted to use.

Before disassembling the laptop, it is important you measure the display area as accurately as possible. In fact, measure it twice or three times to be sure you get the measurements right. This is the area of the display between the plastic parts that frame it, where content can be displayed. You will understand why this is important shortly.

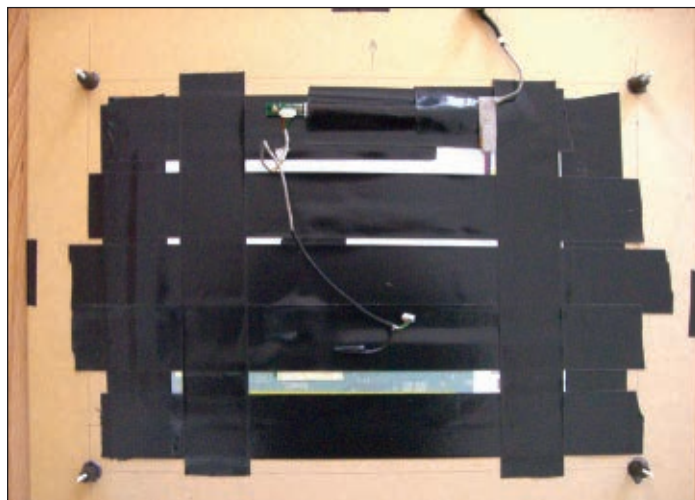
Next, take a deep breath and begin disassembling your laptop. You should do the disassembly on a clean flat surface and try to minimize your movements to avoid static. A grounding strap — while not absolutely required — would be a good precaution.

For some reason, I found the whole disassembly process really fun. Take your time and be careful not to damage anything. Your laptop was designed to snap and screw together so you must perform that process in reverse. If things seem stuck and won't come apart, you have probably missed a screw somewhere; look closely and you will eventually find it.

Special attention is needed when you disassemble the display. You need to remove everything to get to the raw LCD panel. Remove all of the plastic surrounding the display, the hinges, and even the metal bracket used to mount the LCD panel. You should be left with the LCD panel, its cable(s) with connectors and, in my case, a backlight controller built onto one of the cables.

When all is said and done, you will end up with a pile of parts; some you will need, most others you won't.

The stuff you will need includes: the LCD panel with its cables and backlight controller (if separate); the laptop's logic board with RAM and Wi-Fi board (if not built in); all fans; the power switch assembly; the hard drive; and the laptop's power supply (brick).



■ PHOTO 2. LCD display taped to front MDF panel.

The stuff you don't need includes: the laptop's battery; the keyboard; the track pad; CD-ROM drive; modem; and the small mountain of plastic and metal parts, screws, and fasteners.

Then Comes Construction

The first step is to make or buy a matte that fits into the shadow box frame that has the opening cut to the exact dimensions of the display area measured previously.

Next, cut two pieces of MDF so that they both fit easily into the shadow box. One of the MDF pieces is used to mount the display and the other is used to mount the laptop's logic board. Line up one of the MDF pieces

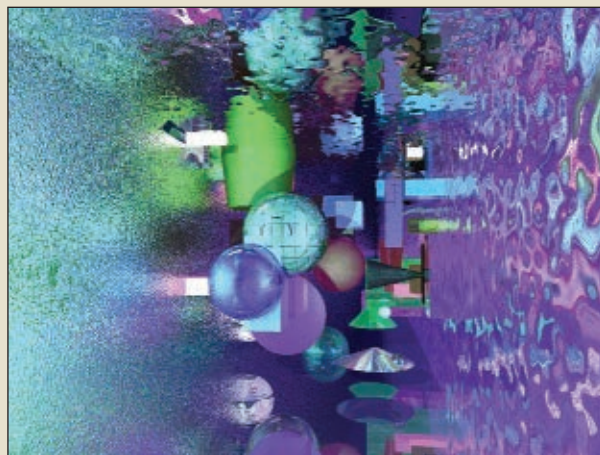
ART RAYS

The Art Rays program enables your LTPF to generate dramatic imagery without human intervention. In other words, Art Rays allows your LTPF to generate its own art dynamically. (And you thought only Bill Gates could have this type of thing!) Art Rays uses raytracing to produce unique, one-of-a-kind, three-dimensional images. See the **photo** for an example Art Rays' image. In fact, I have written a version of Art Rays called Art Rays Lite as an iPhone app available in the iTunes app store. Check it out if you have an iPhone or iPod Touch.

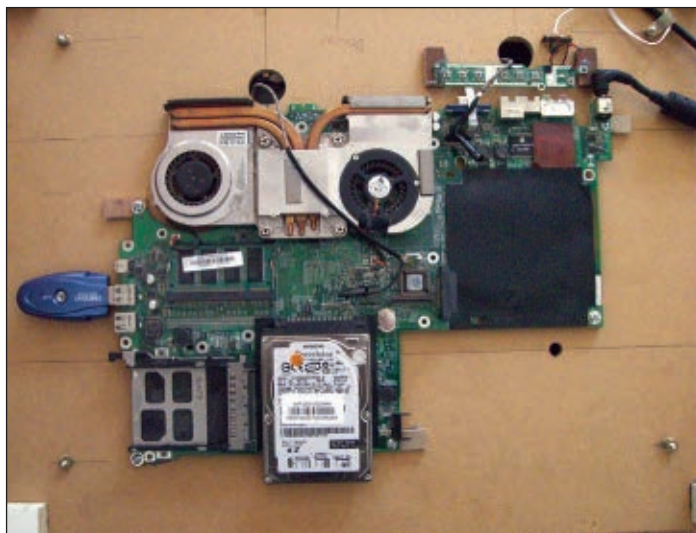
Of course, you have to appreciate ray-traced images to enjoy what Art Rays does. There isn't enough space here to even start to describe the variety and types of images Art Rays generates. As they say, a picture is worth a thousand words so I have made a video of Art Rays images available on the *Nuts & Volts* website (www.nutsvolts.com) to help you decide whether to install Art Rays or not.

Art Rays is based on MegaPOV which is itself based on the amazing POV-Ray — a free raytracing program. You should download POV-Ray, then read and agree to the license agreements before installing and using Art Rays. NOTE: *Art Rays is provided for personal use only. No commercial use of Art Rays or Art Ray images is permitted without written permission from the author.*

To install Art Rays, download the zip file associated with this article from the *Nuts & Volts* website and unzip it into the root of drive C: on your LTPF. Next, create a shortcut to the file `c:\artrays\ArtRays.bat` and place it into the Start folder of your LTPF user. Art Rays will then run automatically when you power-up your LTPF.



■ A ray-traced image generated by Art Rays.



■ **PHOTO 3.** Logic board mounted to the rear MDF panel USB wireless adapter (blue thing on the left). The hard drive is at the bottom. Dual fans cool the CPU. The power switch assembly is in the upper right below the round hole.

with the matte and trace the cutout area onto it. Using a saber saw, cut out the opening for the LCD display. After cutting, sand the edges smooth and verify your LCD display will fit into the cutout.

Once you are satisfied with the fit, paint the MDF (without the LCD) the same color as the matte. Let this dry completely before continuing with the construction.

Cut four wooden spacers from the dowel to the length necessary to hold the second MDF panel above the display which will be mounted in the first MDF panel. Strategically position the spacers to uniformly support the sandwich made from the two pieces of MDF. These spacers will be epoxied to the back of the display board MDF. Drill holes in the logic board's MDF panel for the machine screws protruding through the display

■ **PHOTO 4.** The sandwich assembly made up of the front and rear subassemblies.



MDF and the spacers. A washer and nut on each screw will hold things together. Alternatively, you could use short wood screws to secure both MDF panels to the spacers.

On a clean flat surface, place the display's MDF panel face down and drop the LCD display into it making sure the front of the LCD display is face down, as well. Cut strips of duct tape and run them along all sides of the LCD display, joining the metal rim of the display to the MDF (see **Photo 2**). Press firmly on the tape to remove air bubbles. Flip this assembly over and again run tape on all sides of the display. The duct tape will hold the display firmly in place for a long time.

Turn the assembly back over and epoxy the spacers into place on the rear of the display MDF. Drill the holes in the spacers after they have dried in position. You may want to run some more duct tape to secure the display cables to keep them from flexing too much. You must, however, leave enough slack in the cables so they can be reattached to the logic board.

With the display board finished, place the logic board's MDF panel on the spacers and determine where to drill a hole or holes for the display's cable(s) to pass through in the most natural and stress-free way. Mark and drill these holes with sufficient size to allow the cable(s) and connector(s) to pass through the logic board's MDF panel. You may want to drill a series of 1/4" holes in the logic board's MDF panel to allow air flow for cooling.

Now that you have determined where the display cables feed through, it is time to position and mount the logic board from the laptop (see **Photo 3**). Orient the logic board so the display cables can be plugged in without stretching or stressing the cables. I chose to fabricate small wooden spacers to act as standoffs for mounting the PCB to the MDF. I marked the position of the PCB mounting holes onto the MDF and then epoxied the 1/4" wooden spacers into position. I drilled small pilot holes in the spacers for the wood screws used to secure the PCB to the MDF panel. I then attached the logic board to the MDF panel.

In the laptop I used, the power switch was mounted to its own PCB which attached to the logic board with a flexible ribbon cable. I therefore chose to mount this power switch assembly close to the logic board so that the flexible cable could be plugged back in. I mounted it using the same technique I used for mounting the logic board's PCB.

At this juncture, it would probably be a good idea to make sure the computer still works before buttoning things up. Plug all of the components back together, make sure the hard disk is in place, connect up the power supply cable, and press the power button. If all is well, your LTPF should boot into the OS. If it doesn't, recheck all cabling until you find the problem. After getting the LTPF to boot, screw the two MDF assemblies together and verify this sandwich can be easily inserted into the shadow box frame.

The final step in the hardware construction process is preparing the real panel of the shadow box. I decided to cut a hole in the back panel to allow the power cable to pass through. You could, of course, wire in a connector for the power but I didn't think it was necessary. Next, I drilled a hole to mount the pushbutton power switch in a convenient position. In addition, I drilled an array of 1/4" holes in the real panel for cooling purposes. After all of the holes were drilled, I spray-painted the rear panel flat black for a professional touch.

Next, I soldered some 24 gauge twisted pair wire to the power switch and soldered the other end across the original power switch on the power switch assembly. This way, either switch can be used to cycle the power. With these steps complete, it is time for final assembly.

Place the shadow box face down and insert the matte into it. NOTE: The glass from the shadow box is not used. Next, place some double-sided tape on each side of the LCD display. This tape will prevent the matte from slipping out of position due to gravity when the LTPF is hung. Carefully insert the subassembly sandwich (see **Photo 4**) into the shadow box and line up the display with the matte. Press the matte down so it adheres to the tape. Make sure the cutout in the matte lines up with the LCD.

I cut four wooden spacers out of 3/4" stock and epoxied them into the corners of the logic board's MDF panel. These spacers prevent the sandwich from moving within the frame as it is now wedged into place with the rear panel of the shadow box (see **Photo 5**). You may or may not need these spacers in your LTPF. Finally, run the power cable through the hole in the rear panel and plug it into the logic board's connector; secure the rear panel to the shadow box.

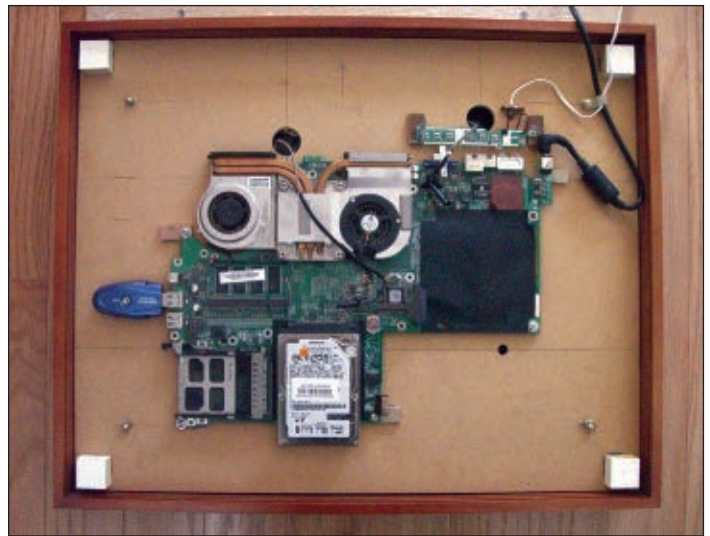
You can now pat yourself on the back for a construction job well done. Software is next.

Controlling The LTPF

Since I had discarded the keyboard and the track pad during the laptop's disassembly process, I needed a way to control the computer's operation. There are at least two ways to do this. You could connect a wireless keyboard and mouse to the laptop (via USB) for control and use a USB Flash drive to move files back and forth to it. With this approach, the LTPF behaves like a normal, non-networked PC.

As for me, I wanted my LTPF on my local wireless network so I could control it remotely. Since the onboard Wi-Fi was broken, I used an inexpensive USB wireless adapter plugged into one of the laptop's USB ports. The approach you take is up to you.

Since my LTPF was running Window's XP Professional, I chose to use Microsoft's Remote Desktop software to control it across the network. See the **Resources** sidebar for info on setting up the remote desktop along with other options for remote control software.



■ **PHOTO 5.** The sandwich assembly placed inside the shadow box. Note the spacers in the corners.

LTPF Software

The first decision you need to make is which operating system your LTPF will run. I stuck with XP Professional. You could, however, run some dialect of Linux such as Ubuntu if you are more comfortable in the Linux/Unix realm. The remainder of this software

RESOURCES

Microsoft's Remote Desktop
Computer remote control software for XP
www.microsoft.com/windowsXp/using/mobility/getstarted/Remoteintro.mspx

TightVNC
Alternative free computer remote control software
www.tightvnc.com

TweakUI
A tool from Microsoft for enabling auto login (among other things)
www.microsoft.com/windowsxp/Downloads/power toys/Xppowertoys.mspx

Flickr screensaver
Slideshow software for a PC
<http://code.google.com/p/slickr-dotnet/>

MegaPOV
The popular collection of unofficial extensions to POV-Ray
<http://megapov.inetart.net>

POV-Ray
Persistence of Vision Raytracer is a high-quality, totally free tool for creating stunning three-dimensional graphics
<http://povray.org>

Video of images mostly generated by Art Rays
www.youtube.com/watch?v=vUbuA7AH8jY

discussion is focused on Window's applications so if you choose some other OS, you have some work to do.

I had two applications in mind when I built my LTPF. First was to provide a slide show of personal photographs like the digital picture frames you buy. For this application, you can use any slide show software you have access to. One choice is the free Flickr screensaver which allows you to display photos from a local directory on the LTPF or to pull in photos from the Flickr website. Again, **Resources** has some pointers for you.

The second application I wanted to run is one I wrote called Art Rays which is described in the sidebar.

Login was a problem I needed to overcome right away as I didn't want to have to log in to the LTPF every time I turned it on. Microsoft came to the rescue here by providing a program called TweakUI which — among other things — can direct an XP box to log in as a specified user every time it is powered up. So, I created a user (LTPFUser) with a password and told Window's via TweakUI to log in this user "automagically." The remote desktop software used for remote control also uses this login for access.

If you have an application you wish to execute as soon as your LTPF starts up, you need to place a shortcut to the application in the Start Folder of the user (LTPFUser, in my case).

Other Project Possibilities

If the sound system works in the laptop you use, you might want to mount the speakers extracted from the laptop into the LTPF. That way, you could play sound during a slideshow or you could use it for pranks where voices seem to come out of nowhere.

If you have a laptop with a broken display, you might disassemble an external LCD monitor and couple it to the laptop via a VGA cable, and then mount both assemblies inside the picture frame.

In terms of other applications for your LTPF, you could run an RSS reader and display stock market graphs, weather data, or other feeds of interest.

This was a fun project for me and it turned out nice enough to hang in our living room. I hope your LTPF turns out as well and that you come up with your own interesting and creative ways to use it. Cheers! **NV**

ABOUT THE AUTHOR

Craig Lindley is a degreed hardware engineer who, until recently, had been writing large-scale Java applications. Now in retirement, he designs and builds the projects he wants to. He can be contacted at calhjh@gmail.com.



Biped BRATs



Round 3DOF Hex



Mini 2DOF Hex



Bipeds



Johnny 5



A4WD1



AL5C Arm



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C&K L Series. DPDT slide switch. Rated 4A @ 125Vac. Plastic handle and body. Body is 0.76" x 0.43". Mounting holes on 1" centers. Solder loop terminals. UL, CSA.

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45¢ each

10 for 40¢ each

LARGE, SURFACE-MOUNT PUSHBUTTON

S.P.S.T., normally-open, momentary pushbutton switch. 1.6" diameter metal body with mounting flanges, holes on 2.3" centers. Originally for automotive horn application. 0.84" diameter black push-button, 0.95" overall height. Packaged with 2 mounting screws.

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LOW VOLTAGE TESTER

NuTone # RCDT900. Convenient test light for 5-30 Volts AC or DC. Marketed as a Door Chime Diagnostic Tool, consists of an enclosed light bulb with two test leads. Light glows, brightness varying with voltage, when power is present. Leads snap into back of unit for compact storage.

CAT# LVT-2



\$2.50 each

12 VDC 1.5 A SWITCHING POWER SUPPLY

Input: 100-120Vac, 50/60Hz. Output: 12Vdc 1.5A. 6' cord. 2.1mm coax power plug. Center positive. UL.

CAT# PS-12151



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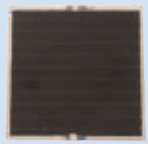


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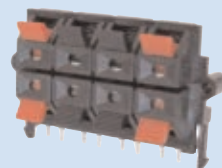
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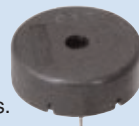
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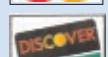
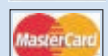
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Explore USB with WinUSB



If you're developing a device that needs to talk to a PC, the chances are good that USB will be involved. For each USB device, the PC assigns a software driver. Windows provides drivers for devices that fit into defined USB classes such as human interface, printer, or mass storage. If your device doesn't fit a defined class, Microsoft's WinUSB driver is an option.

In this article, I'll show how to program and access WinUSB devices. The WinUSB driver requires a PC with Windows XP SP2 or later, including Windows Vista and Windows 7.

A Transfer Type for Every Purpose

Every USB data transfer is between a PC or other USB host computer and a device endpoint. A device endpoint is a buffer that stores received data or data to transmit. Every device must support endpoint zero, which is bidirectional. Additional, optional endpoint addresses each have a number (1-15) and a direction (IN or OUT).

Even though endpoints reside on devices, the USB specification defines endpoint direction from the view of the host PC. An IN endpoint sends data to the PC, and an OUT endpoint receives data from the PC. This naming convention can be confusing when writing code for the device side!

One reason why USB is so versatile is its support for four transfer types, each with different strengths. WinUSB supports control, bulk, and interrupt transfers. Control transfers use endpoint zero. The other transfer types can use endpoints one and higher.

Control transfers provide a structured way to send requests and data and receive responses. Control transfers are the only type that can pass information in both directions in a single transfer. After device attachment — in a process called enumeration — the host computer uses control transfers to learn about the device. WinUSB devices can also use control transfers to send and receive data in vendor-defined requests. For example, you can define a request to set or read a switch, send data to configure device operation, or receive a sensor reading.

A control transfer has two or three stages. To learn about a newly attached device, the host computer uses control transfers to request data structures called descriptors from the device. In the Setup stage, the host sends the request. In the Data stage, the device sends the requested descriptor. In the Status stage, the host acknowledges receiving the descriptor. A host can also use control transfers to send information to a device in the Data stage, with the device acknowledging in the Status stage. Some requests have no Data stage.

A USB host reserves a portion of the bus bandwidth for control transfers: 10% for low- and full-speed endpoints and 20% for high-speed endpoints. If the bus isn't busy, control transfers can use more than the reserved bandwidth. All devices must share the bus, so on a busy bus a control transfer may have to wait.

The other transfer types don't have multiple stages and can transfer data for any purpose. On an otherwise idle bus, bulk transfers are the fastest. Bulk transfers have no guaranteed bandwidth, so on a busy bus bulk transfers must wait. Common uses for bulk transfers are printers and scanners, where quick transfers are nice but not essential.

For interrupt transfers, the host guarantees a maximum interval between requests for data from IN endpoints or sending data to OUT endpoints. Common uses for interrupt transfers are mice and keyboards, which need to transfer user input quickly to the host computer.

Isochronous transfers have a guaranteed transfer rate but unlike the other transfer types, isochronous transfers don't use acknowledgements, and the receiver has no defined way to request re-transmitting corrupted data. Common uses for isochronous transfers are streaming audio and video, where users won't notice or will tolerate a few corrupted or missing packets. WinUSB doesn't support isochronous transfers.

Using the USB Framework

My example code is for Microchip's PIC18F4550 microcontroller and MPLAB C18 compiler. I tested the code on their PICDEM FS-USB development board. A complete WinUSB project for the PIC along with companion Visual Basic and Visual C# applications are available from my website (see **Sources**).

My PIC code uses Microchip's free USB Framework, which is a set of source-code modules that handle low-level USB communications. Using the Framework can save much time and trouble.

For each endpoint besides endpoint zero, the device provides an endpoint descriptor.

Listing 1 shows endpoint descriptors for bulk and interrupt endpoints in each direction.

The USB Framework defines constants that help make the code more readable and easier to maintain. For example, in **Listing 1**, `USB_DESCRIPTOR_ENDPOINT` is the constant `0x05` which the USB specification defines as the value that identifies an endpoint descriptor.

Other descriptors include the device descriptor, which contains the device's Vendor ID (VID) and Product ID (PID), and one or more

LISTING 1

```
// Endpoint descriptors

0x07, // Descriptor size in bytes
USB_DESCRIPTOR_ENDPOINT, // Descriptor type
_EP01_OUT, // Endpoint number and
           // direction
_BULK, // Transfer type
0x40, 0x00, // Endpoint size in bytes
0x00, // Ignored for bulk endpoint

0x07, // Descriptor size in bytes
USB_DESCRIPTOR_ENDPOINT, // Descriptor type
_EP01_IN, // Endpoint number and
          // direction
_BULK, // Transfer type
0x40, 0x00, // Endpoint size in bytes
0x00, // Ignored for bulk endpoint

0x07, // Descriptor size in bytes
USB_DESCRIPTOR_ENDPOINT, // Descriptor type
_EP02_OUT, // Endpoint number and
           // direction
_INT, // Transfer type
0x08, 0x00, // Endpoint size in bytes
0x0A, // Endpoint interval

0x07, // Descriptor size in bytes
USB_DESCRIPTOR_ENDPOINT, // Descriptor type
_EP02_IN, // Endpoint number and
          // direction
_INT, // Transfer type
0x08, 0x00, // Endpoint size in bytes
0x0A, // Endpoint interval
```

Listing 1. Endpoint descriptors tell the USB host about all endpoints in addition to the required endpoint zero.

interface descriptors that specify an interface number and how many endpoints belong to the interface. The USB 2.0 specification defines the fields in the descriptors.

Bulk and Interrupt Transfers

To read and write to endpoints, program code accesses an endpoint's buffer descriptor (BD). To program USB Framework communications on PICs, you need to understand BDs.

A BD consists of four byte-wide registers that hold information about an endpoint's most recent data transfer or the next data transfer. The microcontroller core and the USB module share ownership of the BD. The microcontroller core is the CPU that executes the code — or firmware — that you program into the device. The USB module — also called the serial interface engine (SIE) — provides hardware support for USB communications. A `USB_HANDLE` is a pointer to an endpoint's BD. The key to accessing a BD is its `UOWN` bit. When `UOWN = 0`, the microcontroller core owns the buffer, and firmware can read and write to the BD. When `UOWN = 1`, the USB module owns the BD, and firmware can read `UOWN` but should not read or write to other locations in the BD.

Listing 2 shows code for reading received

LISTING 2

```
***
#define WINUSB_BULK_EP 1
#define WINUSB_BULK_IN_EP_SIZE 64
#define WINUSB_BULK_OUT_EP_SIZE 64

WORD bulk_bytes = 0;
USB_HANDLE USBWinUsbBulkOutHandle;
unsigned char
winusb_bulk_in_buffer[WINUSB_BULK_IN_EP_SIZE];
unsigned char
winusb_bulk_out_buffer[WINUSB_BULK_OUT_EP_SIZE];

// Set up the endpoint to enable receiving data.

USBWinUsbBulkOutHandle = USBGenRead(WINUSB_BULK_EP,
    (BYTE*)&winusb_bulk_out_buffer,
    WINUSB_BULK_OUT_EP_SIZE);

if(!USBHandleBusy(USBWinUsbBulkOutHandle))
{
    // The microcontroller core owns the endpoint.
    // Check for received data.

    bulk_bytes =
    USBHandleGetLength(USBWinUsbBulkOutHandle);

    if (bulk_bytes > 0)
    {
        // Data was received.
        // Copy it to for sending back to the host.

        for (count; count <= bulk_bytes - 1; count++)
        {
            winusb_bulk_in_buffer[count] =
            winusb_bulk_out_buffer[count];
        }
    }
}
```

Listing 2. When the microcontroller core owns an OUT endpoint, firmware can check for data received from the host.

LISTING 3

```
***
USB_HANDLE USBWinUsbBulkInHandle;

if (!USBHandleBusy(USBWinUsbBulkInHandle))
{
    // The microcontroller core owns the endpoint.
    // Prepare to send data to the host.

    USBWinUsbBulkInHandle = USBGenWrite(WINUSB_BULK_EP,
        (BYTE*)&winusb_bulk_in_buffer, bulk_bytes);
}
```

Listing 3. When the microcontroller core owns an IN endpoint, firmware can write data to the endpoint for sending to the host.

data on a bulk OUT endpoint. (Remember that an OUT endpoint receives data from the host.) The USB Framework's `USBGenRead` function handles many details of preparing the endpoint to receive data. The function accepts an endpoint number, a pointer to a buffer to hold received data, and the maximum number of bytes to receive. The function sets up the transfer, sets `UOWN = 1` to transfer BD ownership to the USB module, and returns a pointer to the BD.

The USB module then manages the data transfer without further intervention by firmware.

When the endpoint receives an OUT token packet followed by data, the USB module stores the data in the passed buffer and sets `UOWN = 0` to transfer BD ownership back to the microcontroller core.

To check for received data, the Framework's `USBHandleBusy` macro first checks to see if `UOWN = 0`. If so, the `USBHandleGetLength` macro returns the number of bytes received. Firmware can retrieve and use the received data in any way. **Listing 2** copies the data into `winusb_bulk_in_buffer` for sending back to the host in a basic loopback test. After retrieving the data, firmware can call `USBGenRead` again to prepare the endpoint to receive new data.

Listing 3 shows code for sending data to the host from a bulk IN endpoint. To send data, `USBHandleBusy` first checks to see if `UOWN = 0`. If so, a call to `USBGenWrite` prepares to send the data. The function accepts an endpoint number, a pointer to a buffer that holds the data to send, and the number of bytes to send. The function sets up the transfer, sets `UOWN = 1` to transfer BD ownership to the USB module, and returns a pointer to the BD.

The USB module then manages the data transfer without further intervention by firmware. On receiving an IN token packet at the endpoint, the USB module sends the data and sets `UOWN = 0` to pass ownership back to the microcontroller core. Firmware can then prepare for another transfer.

At the device, bulk and interrupt transfers are identical except for the endpoint type. The only difference is in scheduling by the host. So, to convert **Listings 2** and **3** for use with interrupt transfers, just replace every instance of *bulk* with *interrupt* and set `WINUSB_INTERRUPT_EP = 2` (or whatever endpoint number the interrupt endpoint addresses are using) and set `WINUSB_INTERRUPT_IN_EP_SIZE` and `WINUSB_INTERRUPT_OUT_EP_SIZE` to match the endpoint sizes in the endpoint descriptors.

Control Transfers

Because of their multiple stages, control transfers are more complicated to program than bulk and interrupt transfers. The first step in responding to a control transfer is to detect the received request. From information received in the Setup stage, firmware can learn whether the request is directed to the whole device or to a specific interface in the device.

Listing 4 checks values received in the Setup stage to find out if the request is directed to the WinUSB interface and if the firmware has defined the request. If so, the function examines the Setup data to determine whether the host or

Get Ready for SuperSpeed USB

USB 2.0 has served devices well for a decade. Now, USB 3.0 promises to extend the interface for the future.

The USB 3.0 specification — released in November '08 — defines a new, SuperSpeed bus that operates in parallel with USB 2.0's wires. The 5 Gbps signaling rate is over 10 times faster than USB 2.0's top speed of 480 Mbps (see **Table**).

Plus, unlike USB 2.0, SuperSpeed has a pair of wires for each direction so traffic can move in both directions at once. The first SuperSpeed devices will likely be drives and high-resolution video.

You don't need to worry that all of your USB 2.0 devices will soon be obsolete, however, USB 3.0 supplements not replaces USB 2.0. A USB 3.0 host must support USB 2.0 speeds.

Where possible, USB 3.0 builds on USB 2.0. SuperSpeed devices use the same four transfer types, descriptors (with some additions), USB classes, and hub topology.

USB 3.0 also offers advances in power use. SuperSpeed devices can draw up to 900 mA per device, compared to 500 mA for USB 2.0. When reducing power is feasible, USB 3.0 defines new power-saving modes.

Every SuperSpeed device must support at least one USB 2.0 speed, but the device doesn't have to fully function at that speed. The device might just return a message saying that the device needs a SuperSpeed host to perform its function.

USB 3.0 host and device controllers are just beginning to be available. Windows 7 will add support for USB 3.0 in a future service pack.

Bus Speed	Bus Signaling Rate (Mbps)	Channel Type	Max Cable Segment (meters, typical)	Typical Use
Low	1.5	Half duplex*	3	Mouse, keyboard
Full	12	Half duplex*	5	Virtual COM port
High	480	Half duplex*	5	Mass storage, video
Super Speed	5,000	Dual simplex**	3	High-performance mass storage, video

* Both directions take turns on one pair of wires.

** Each direction has its own signal pair and ground wire.

USB 3.0's SuperSpeed is over 10 times faster than USB 2.0's high speed.

Sources

WinUSB Example Firmware and Applications
www.Lvr.com

PIC18F4550, PICDEM FS-USB board,
USB Framework
www.microchip.com

Windows Driver Kit (WDK) and
WinUSB Co-installers
www.microsoft.com

LISTING 4

```
***
// Check the Setup packet to find out if the request
// is directed to an interface, names the WinUSB
// interface ID, and is a Vendor request.

if(SetupPkt.Recipient != RCPT_INTF) return;
if(SetupPkt.bIntfID != WINUSB_INTF_ID) return;
if(SetupPkt.RequestType != VENDOR) return;

// It's a vendor-specific request to the WinUSB
// interface. Decode the request and call a routine
// to handle it.

switch(SetupPkt.bRequest)
{
    case WINUSB_REQUEST_1:

        // The Data stage is host-to-device.

        WinusbControlWriteTransferHandler();
        break;

    case WINUSB_REQUEST_2:

        // The Data stage is device-to-host.

        WinusbControlReadTransferHandler();
        break;
}
```

Listing 4. If the WinUSB firmware has defined a received request, the firmware calls a routine to handle the request.

device sends data in the Data stage and calls a function to handle the request. The example handles two requests. Request 1 has a host-to-device Data stage, and Request 2 has a device-to-host Data stage.

I patterned my code to handle the control-transfer requests after similar code in the USB Framework. For requests where the device sends data to the host, I used the Get_Descriptor request as a model. Code for requests where the host sends data to the device is less common, but I found an example in the Framework's virtual COM port example in the SET_LINE_CODING request.

Installing a Device

The other side of WinUSB communications is the PC software that detects the device, assigns a driver, and exchanges data with the device.

An INF file is a text file that Windows uses to match a driver to a device. The INF file for a WinUSB device includes the VID and PID from the device descriptor and a 128-bit value called a GUID which applications use to identify a specific WinUSB device. The GUID's length and the method used to generate the GUID make it highly unlikely that multiple devices will have the same GUID.

You can generate a GUID in several ways. In Microsoft's Visual Studio Standard edition and higher, select Tools > Create GUID. Other options are Microsoft's GUID generator,

guidgen.exe, or an online GUID generator — both easily found via a web search. To customize my project's WinUSB INF file for your device, replace the GUID and the VID and PID with your values. The GUID is in the [Version] section's ClassGUID item:

```
ClassGUID = {36FC9E60-C465-11CF-8056-444553540000}
```

Replace the value between the curly brackets with your GUID. The device's VID and PID are in the INF file's [Manufacturer] section in this item:

```
%USB\MyDevice.DeviceDesc% = USB_Install,  
USB\VID_0925&PID_1456
```

Replace the VID (0925h) and PID (1456h) with the idVendor and idProduct values in the device descriptor for your device. To install a WinUSB device on Windows XP, the PC must have three co-installer DLLs. Microsoft's free Windows Driver Kit (WDK) contains the files which you can distribute with your software. You don't need to provide the files for Windows Vista systems.

On first attachment, Windows searches for an INF file with a matching VID and PID. If needed, point the Found New Hardware Wizard to the location of the INF file and the co-installer files.

When the device is installed and ready for use, Windows Device Manager shows the device under

Universal Serial Bus Controllers. To view the Device Manager, right-click My Computer and select Manage, then Device Manager.

Wiring Applications

You can access WinUSB devices with Visual Basic or Visual C#, including the free Express editions. Microsoft's .NET Framework doesn't provide a class for accessing WinUSB devices. Instead, applications use Windows API functions and the WinUSB API to detect and communicate with devices.

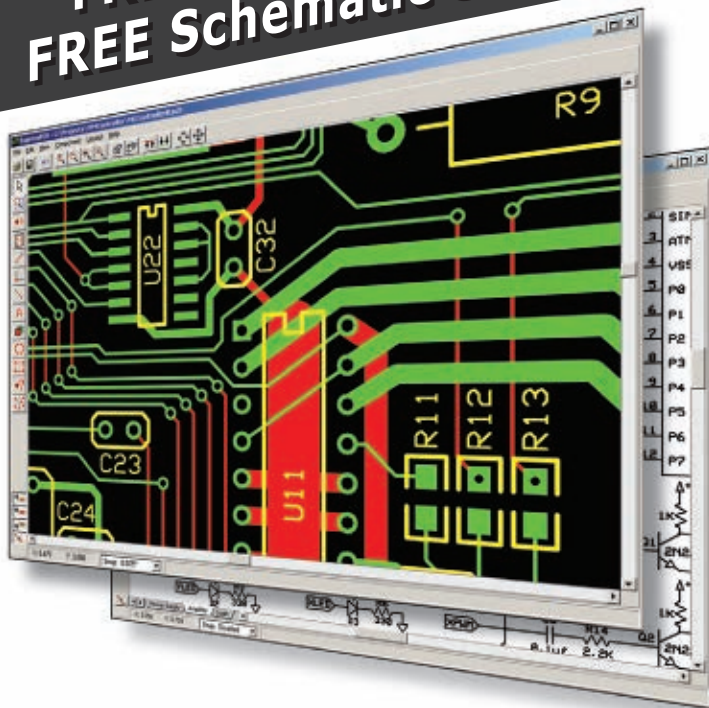
For each API function used, Visual Basic and Visual C# applications must provide a declaration. Writing a declaration requires translating Microsoft's declaration (written in C) to the syntax and data types supported by Visual Basic or Visual C#. To call a function, you provide parameters whose data types match those in the declaration.

API functions can find a specific device by GUID value, obtain a handle for accessing the device, learn the number and type of endpoints, configure timeouts and other behavior, and exchange data using bulk, interrupt, and control transfers. If you're not familiar with calling API functions, the programming can seem obscure, but my example applications show the way.

With this introduction to firmware and applications, you're ready to start experimenting with USB transfers for use in your projects. **NV**

Jan Axelson is the author of *USB Complete* and *Serial Port Complete*. You can reach Jan at jan@lvr.com.

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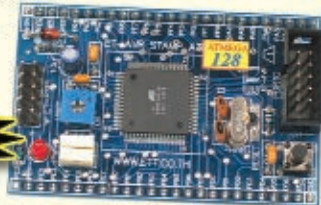
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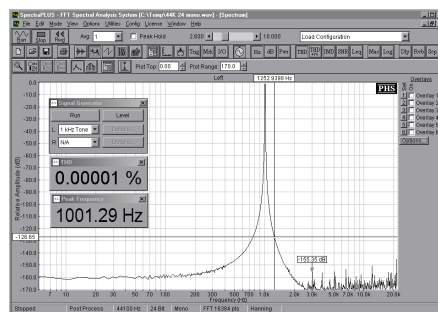
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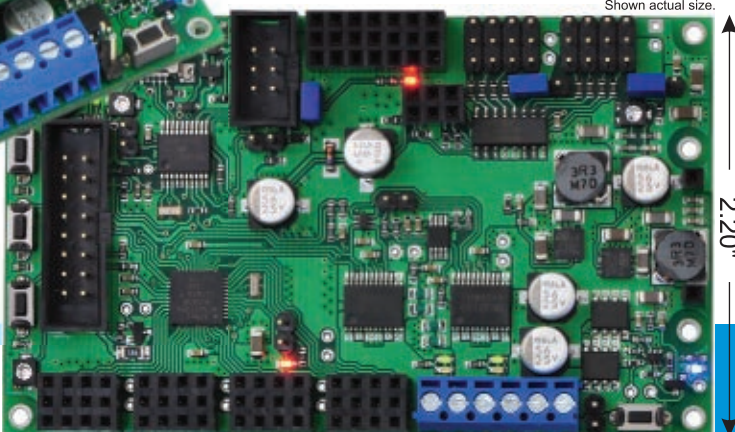
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Experiments with Alternative Energy

Part 6 - Build a Three-Phase AC Wind Turbine

By John Gavlik, WA6ZOK

If Dr. Emmett Brown can build a time machine out of a DeLorean, then I can show you how to build a three-Phase AC Wind Turbine out of a roof ventilator! (Flux capacitor optional.)

Imagine creating a three-phase AC wind turbine from a common, everyday roof ventilator along with some magnets and coils of wire (**Figure 1**). I chose the Whirlybird[™] roof ventilator manufactured by Lomanco and sold at Home Depot for the following reasons:

Figure 1 – Whirlybird Wind Turbine.



1. It has great bearings that simply will not wear out under normal and even severe use. Without great bearings, your wind turbine is always fighting friction that only serves to slow it down with the attendant loss of power.
2. It can be easily constructed with common tools and without soldering or drilling.
3. It can be used indoors with a table fan and [especially] outdoors where your study of day-to-day and season-by-season wind never stops.
4. It produces three-phase AC power just like the commercial wind turbines, which allows you to study this marvelous electrical principle firsthand by using either the Parallax BS2 or PICAXE 28X2 processors and your computer.
5. You will be able to easily modify it in order to study the effects of magnetism and how you can optimize the mechanical components to produce maximum power.

Why Use a Roof Ventilator?

Several years ago while looking for an “easy” way to construct a wind powered electrical alternator, I discovered almost everyone who makes a homebrew wind turbine starts with a very complicated and expensive hub

to hold the rotating magnets, followed by making their own custom-made blades. Then, they design an even more complex widget to attach this assembly to bearings to make it spin smoothly. This is followed by adding some kind of wood or metal support to prop it up to hold everything together.

I didn’t want any of this for my wind turbine. Since I’m mechanically challenged in the first place, I felt that there had to be another way to do the same thing — only faster, cheaper, and better without getting into a major DIY project.

So, that’s why I chose a roof ventilator. On a visit to Home Depot, I saw one and it dawned on me ... this has all the things I need for an educational electrical wind alternator, plus it was off the shelf, relatively inexpensive, and quite elegant in its design and simplicity for the task at hand. Think about it ... if all the roof ventilators on all the rooftops in the entire world were also three-phase AC wind alternators, a great deal of energy problems would be solved — with zero pollution. Before I get into how to build it, let’s learn a bit about the technology first.

Wind Turbine Primer

There are two basic types of modern electrical wind turbines: horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). The Whirlybird is of the

VAWT variety. The big ones you see from the highway are of the HAWT type. There are variations on both designs (see sidebar) but these are the two fundamental ones.

Every wind turbine that generates electrical power uses a form of alternator that consists of two parts: a rotor and a stator. The rotor is a series of magnets that spin above or next to groups of fixed coils which are the stators. Sometimes the rotor and stators are reversed with the coils as the rotating element and the magnets fixed, but not very often. Basically, there needs to be a way for the wire coils to “communicate” their electrical energy to a fixed set of wires that lead out of the turbine to supply the load with power. Refer to the sidebar on *Alternators versus Generators* to understand the difference.

All commercial wind turbine electrical alternators are made up of three major parts: the blades that are spun by the wind; a gearing mechanism that increases the rpm spin rate of the blades; and this connection through an output shaft that is attached to an alternator that converts the rotating mechanical energy into electricity. Since the intent of these experiments is to demonstrate how three-phase electricity is produced at lower wind speeds and power levels, our design here leaves out the gearbox for simplicity and lower cost.

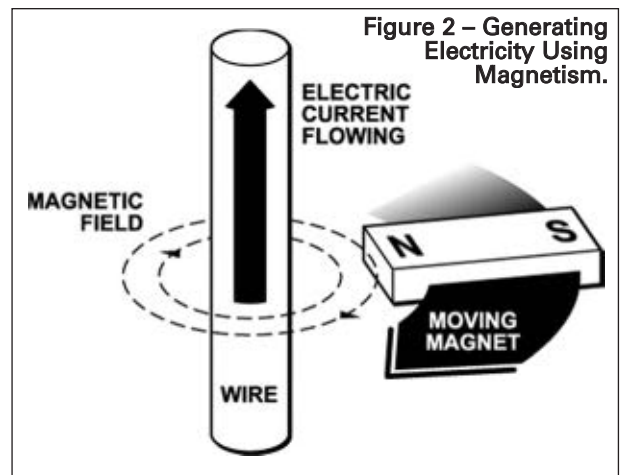
Generating Electricity with Wires and Magnets

All alternators work because of the effect of moving magnets by a wire. When electrons flow through a wire, a magnetic field is created around it. Similarly, when a magnetic field moves past a wire, electrons are generated through it. Therefore, by moving magnets past a wire, electrons are made to move through the wire thereby generating electricity. Instead of having a single wire (as shown in **Figure 2**), we could have many individual wires

with the same current of electricity being generated in each one. Much more voltage current could be generated this way.

Since it is not practical to have multiple individual, interconnected wires, coils of wire are used where magnets rotate over them to produce electricity. For example, when the North pole of a magnet passes over a coil, current flows in one direction; when the South pole of a magnet passes over the same coil, current flows in the opposite direction. The most current is generated when the magnetic field is at 90 degrees to the coil windings; when the magnetic field is parallel to the coil windings, no electrical current is generated. Ideally, you want each radial leg of a coil to be over a magnet at the same time — one leg over a North pole and one over a South pole. This is a noble goal, but our model does not have it. Nevertheless, our magnet-coil arrangements do come close.

In **Figure 3**, you can see how current in the left radial leg of the coil is directed upwards (clockwise) by the North pole of one magnet, and the right radial leg is directed downwards (also clockwise) by the South pole of the next magnet. If both radial legs are over magnets



with the same polarity (i.e., both North poles), the generated currents would cancel each other out. Therefore, alternator rotors — including ours — are made up of magnets with alternating polarities: N, S, N, S, and so on. As such, surprisingly the electrical output is not Alternating Current (AC) with the direction changing every time the magnets pass over the coils. If the coils and magnets are correctly aligned, the resulting output looks like a sine wave (**Figure 4**).

Factors that Influence Total Power Output

The voltage and current [or power] generated by the magnets spinning over the coils depends on the following criteria:

- The strength of the magnets.
- The wire gauge and the number of

Alternators versus Generators

The key difference between an alternator and a generator is what spins and what is fixed. On a generator, windings of wire (the armature) spin inside a fixed magnetic field. On an alternator, a magnetic field is spun over or next to windings of wire called a stator. This allows the wires to be directly and easily connected to their outputs without the need for sliding contacts to carry the relatively high output current.

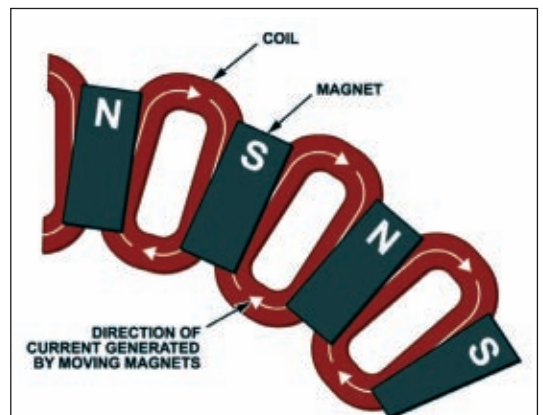


Figure 3 – Effect of Magnetic Poles on Electricity Generation.

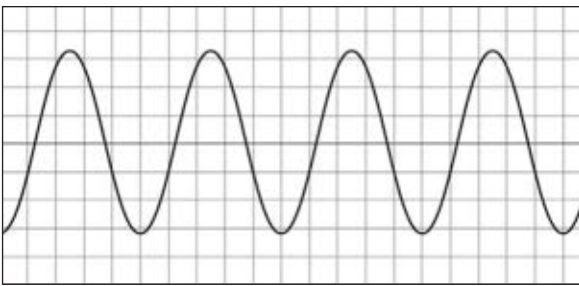


Figure 4 – Sine Wave Alternator Output.

power output. But I'll get to these in their time. For now, I'll address the above points one at a time. I've provided some excellent links in the sidebars if you'd like to learn more than I've presented here.

Magnetic Strength

Magnetic strength is known by several different names depending on whether you're an electrical engineer (magnetic flux density), mathematician (magnetic induction), or a physicist (magnetic field). I'll use flux density for purposes

here. Just remember, the higher the flux density, the higher the strength of the magnetic field.

One measure of flux density is the Gauss, named after the German mathematician Karl Fredric Gauss (177-1855). For example, the Earth's magnetic field is about 0.5 Gauss while a small refrigerator magnet is about 100 Gauss. A good laboratory magnet is rated at 100,000 Gauss and the 16 ferro magnets in our Whirlybird three-phase AC wind turbine are rated at 3,950 Gauss each (see sidebar). This is not a formal definition or exhaustive explanation of magnet strength; rather, it's just enough for you to become acquainted with the concept. You can find out much more on the Web if you're so inclined.

Wire Gauge and Coil Turns

For most commercial wind turbines, regular copper wire coils are used to capture the magnetic flux created by the rotating magnets in order to convert it into electricity. As you would expect, the more turns per coil, the more magnetic flux that can be captured and turned into voltage and current. Also, the wire gauge determines the maximum amount of current that can flow. The tradeoff is really the magnetic strength versus the wire gauge and number of turns. A balanced use of both will produce optimum results.

Magnet-Coil Separation

Magnet-coil separation is critical to generating maximum power; for maximum magnetic coupling, the closer the better. One of the experiments for the Whirlybird involves adjusting the distance between the spinning magnets and the stationary coils by adding and removing regular flat washers. By performing this experiment, you can see how the mere thickness of a flat washer can affect the power output by over 50%! While it's not part of our Whirlybird wind turbine, **Figure 5** shows a 70+ year old disassembled alternator from Hoover Dam in Nevada. The diameter of this monster is over 30 feet wide, while the distance between the coils and magnets are measured in the thousands of an inch. (Imagine the precision workmanship that went into building this in the 1930s, without the aid of any computing technologies. These alternators are still in operation today!)

Rotational Speed

Rotational speed of the magnets is where the most dramatic effects of power generation can be witnessed; the faster, the better, but within limits.

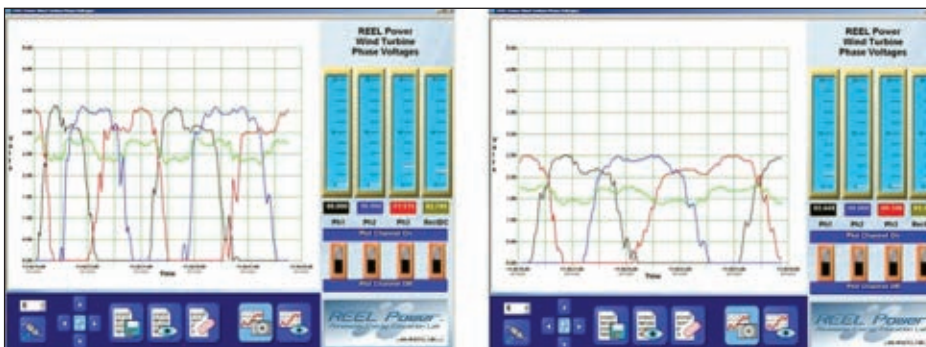
Figure 6 – Plots of Three-Phase Voltage Measurements at High and Low rpms.

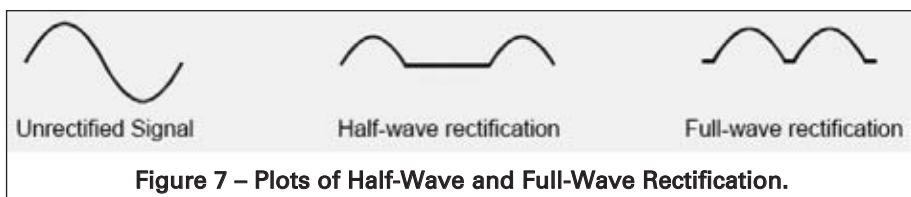


Figure 5 – Disassembled Hoover Dam Alternator.

- turns of wire in the coils.
- The distance between the coils and the spinning magnets (very important!).
- The speed of the magnets passing over the coils (the basic reason for the gearbox).
- The type of coil arrangement: Single-phase or Three-phase.
- The three-phase coil wiring arrangement: Star or Delta.
- The full-wave rectifier diodes that convert three-phase AC to rectified DC.

While this is a mouthful by itself, there are still additional considerations with respect to wind speed and blade type that affect





In effect, the faster the magnetic lines of force are “cut” by the coils, the more voltage and current gets generated. **Figure 6** shows our Whirlybird generating electricity at two different rpms. As you can see, the voltage peaks of the three-phase voltages, as well as the average voltage (green plot), vary proportionally with rotor speed. The plots in **Figure 6** are what the BS2 and 28X2 processors detect (via the A/D converter) and display on the computer for your wind experiments.

Single-Phase versus Three-Phase

Single-phase electricity is like the 110 VAC coming from your wall socket. It’s good enough for powering small motors like hair dryers and electric drills for short periods of time, but it is quite inefficient for continuous use, as in factory motors or wind turbine

alternators. Single-phase electricity varies from zero volts to peak volts – both plus and minus – and back to zero again with the attendant power varying in the same way; that is, going to zero twice in every cycle. This can be seen in **Figure 7** where the single-phase voltage is half-wave and full-wave rectified. While the average generated voltage and current is somewhere in between (depending on factors like load), it still suffers from the fact that power goes to zero.

In contrast, three-phase power never goes to zero. This is because a three-phase alternator uses three independent sets of coils that are spaced 120 angular degrees apart. The three full-wave rectified phases combine to produce a waveform like that in **Figure 8**. The important concept to realize is that since the three coils are spaced equally apart at 120 angular degrees, each of them reaches its instantaneous peak

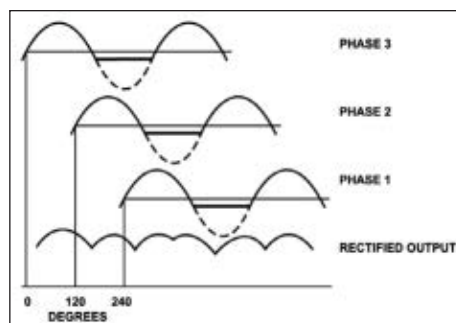


Figure 8 – Plot of Three-Phase Full-Wave Rectification.

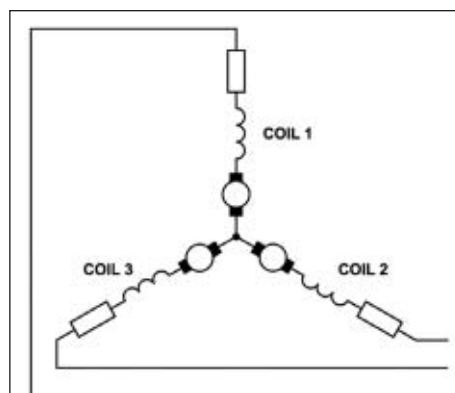
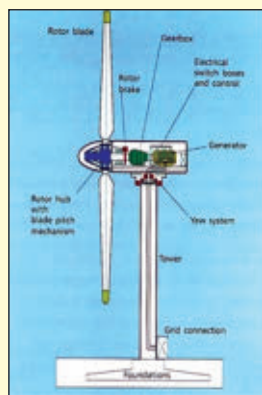


Figure 9 – Star Three-Phase Coil Arrangement.

at different times depending on the rotational speed of the rotor. When the individual phases are combined by rectifier diodes, the voltage and

Types of Wind Turbines



Horizontal Axis (HAWT)

Horizontal axis wind turbines have the main rotor shaft and electrical alternator mounted at the top of a tower; the entire mechanism must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor to move the entire top assembly. Most have a gearbox that increases the slow rotation of the blades to a speed that is more suitable to drive an electrical alternator. The greatest disadvantage of this type of turbine is its physical size, mounting requirements, complex and trouble-prone gearbox, blade pitch adjustment controls, and the need to position the blades into the wind. That said, they are the most popular and efficient ones built to date. *Image courtesy of www.Wikipedia.com.*

Vertical axis (VAWT)

Vertical axis wind turbines have the main rotor shaft arranged vertically. A key advantage is that the turbine does not need to be pointed into the wind to be effective. This is helpful on sites where the wind direction is highly variable. VAWTs can utilize winds from varying directions with the same performance; however, their guy wires occupy considerable land area. With a vertical axis, the alternator and gearbox can be placed near to or on the ground so it is more accessible for maintenance. The drawbacks are that some designs produce pulsating torque and drag may be created when the blades rotate into the wind. There is also much less wind at ground level as compared with the HAWT types. Contrary to first impressions, the mechanical maintenance is far greater in that the entire blade assembly must be torn down to get to the gearbox and other mechanical elements. New commercial VAWTs are rarely built these days. The one shown here is actually rusting away on a hill overlooking the St. Lawrence Seaway in Canada.

Photo credit www.reuk.co.uk.



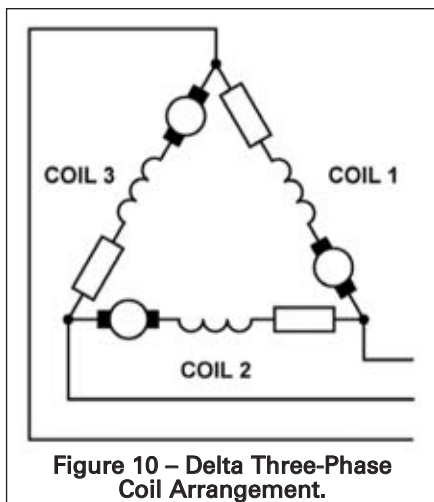


Figure 10 – Delta Three-Phase Coil Arrangement.

current (and thus the power) never go to zero.

The overall tradeoff between single-phase and three-phase is that three-phase devices require three times more copper windings, more physical space, and slightly more diode rectification. Nikola Tesla developed the “non-commutator” three-phase AC motor and revolutionized electricity as we know it today. All industrial motors and alternators are now three-phase. Were it not for Tesla and his financial backers (like J.P. Morgan and George Westinghouse), we would not have advanced the state of electricity or electronics anywhere near as fast.

Star versus Delta

There are two basic ways to create three-phase electricity and they involve how the three separate



Figure 11 – Wind Turbine on Fire.
(Photo courtesy of Freemage.org.)

coil arrangements are hooked up. Coils can be arranged in two configurations: Star and Delta.

In the Star arrangement, the start of each of the three phases is connected together in the center; they can either “float” or be grounded. Connections are taken from the ends of the three phases to produce the three-phase outputs. This is called a Star or Wye arrangement because it looks like a crude shaped star or an inverted “Y” (Figure 9). The Delta arrangement (Figure 10) has the end of phase 1 connected to the start of phase 2; the end of phase 2 to the start of phase 3; and the end of phase 3 to the start of phase 1. Connections are taken from the three start end points to produce the three phases. The fundamental difference between the

Star and Delta arrangements is that the Star generates a higher voltage at a lower current while the Delta generates a lower voltage at a higher current for the same magnet rotational speed.

As it turns out, commercial wind turbines switch between the Star and Delta depending upon load and wind speed. When just



Figure 12 – Whirlybird Wind Turbine Rotor Assembly.

spinning up to speed, the wind turbine’s electronic controller will switch the alternator coils to the Star arrangement where higher voltages can be achieved quickly as the turbine blades spin up. Then at the appropriate time, the controller will switch the coils to the Delta arrangement to supply more current into the load and to actually slow the wind turbine’s spin rate; otherwise, if left in the Star configuration in high winds, it would spin too fast and destroy itself in the process (Figure 11). Next time you look at a commercial wind turbine, realize that there is a microprocessor or two, in control of the coil switching task.

Building the Whirlybird

I’m going to condense the building process to some very basic steps as I fast forward through the assembly procedure. You can find complete details for assembling the Whirlybird at the following link: www.learnonline.com → Menu → User Manuals and Quick Looks → Whirlybird Wind Turbine User Manual.

First, you will need to purchase a Whirlybird roof ventilator (Lomanco model B1B-12) from Home Depot or a similar home improvement store. They cost about \$30. The rest of the hardware and their sources are provided in the **Parts List** here.

To begin, construct the rotor that consists of 16 ferrite magnets arranged in an alternating North-South-North-South manner

Examples of Flux Density

Smallest value in a magnetically shielded room	10 ⁻¹⁴ Tesla	10 ⁻¹⁰ Gauss
Interstellar space	10 ⁻¹⁰ Tesla	10 ⁻⁶ Gauss
Earth’s magnetic field	0.00005 Tesla	0.5 Gauss
Small bar magnet	0.01 Tesla	100 Gauss
Within a sunspot	0.15 Tesla	1500 Gauss
Small NIB magnet	0.2 Tesla	2000 Gauss
Big electromagnet	1.5 Tesla	15,000 Gauss
Strong lab magnet	10 Tesla	100,000 Gauss
Surface of neutron star	100,000,000 Tesla	10 ¹² Gauss
Magstar	100,000,000,000 Tesla	10 ¹⁵ Gauss

What is a Tesla? It is a unit of magnetic flux density. It is also equivalent to these other units:
 1 Weber per square meter
 10,000 Gauss (10 kilogauss)
 10,000 magnetic field lines per square centimeter
 65,000 magnetic field lines per square inch.

Source www.coolmagneticman.com

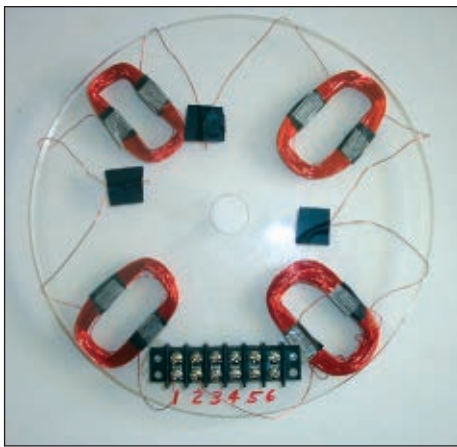


Figure 13 – Phase 1 Stator Coil Windings.

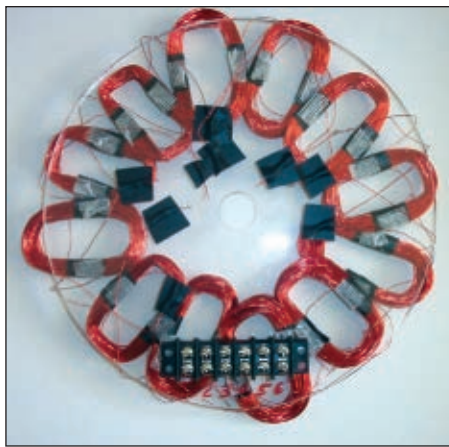


Figure 14 — Completed Three-Phase Stator Coil Arrangement.

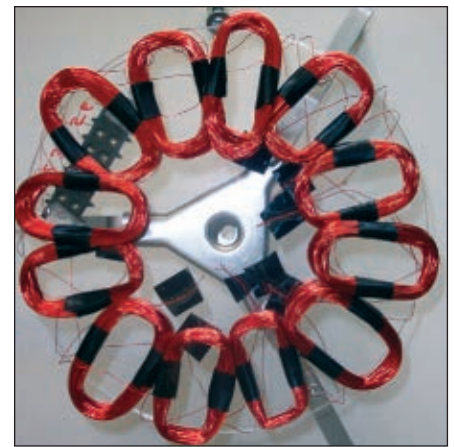


Figure 15 — Stator Coils Mounted on Triangular Base.

around the perimeter of an eight inch metal disk (**Figure 12**). Epoxy the magnets to the metal plate to hold them in place; the back of the metal rotor disk is then epoxied to the three struts of the turbine fan. Notice the shaft coupler attached to the end of the rotor shaft. This will attach to the stator mechanism described next.

The stator is made up of three groups of four coils that form the three-phase windings. Each of the four coils is wired from end to end in series with the end wires going to two terminals of a six-position

terminal strip (**Figure 13**). The other two sets of coils are wired the same way; however, they are physically placed next to one another like the numbers on a clock face with the Phase 1 coil set at 12, 3, 6, and 9 o'clock; the Phase 2 coil set at 1, 4, 7, and 10 o'clock; and the Phase 3 coil set at 2, 5, 8, and 11 o'clock (**Figure 14**).

With the coils coming out to the terminal connector this way, you will be able to wire the coils in either a Star or Delta configuration. The stator is mounted to the triangular base with epoxy glue (**Figure 15**); notice that the coils face up and the six-position terminal strip is on the opposite (bottom) side.



The two halves are joined

together with a 1-½ inch bolt, the shaft coupler mentioned above, a hex nut, and some spacer washers to keep the rotating magnets from touching the coils (**Figure 16**). When the two halves are screwed together, give the fan assembly a gentle spin. If you don't hear any scraping sounds, you've done things right; otherwise, simply disassemble the two halves and add a washer or two for more magnet-coil separation. There is no need for drilling, soldering, or any custom work. If you assemble the unit as I've described here, you will be able to later disassemble and reassemble it in order to optimize it for best performance with very little difficulty.

Whirlybird Wind Turbine Parts List

Qty	Description
12	Wire coils
16	Bar magnets
1	Six-position terminal block
1	8" diameter round metal rotor disk
1	8" diameter round Plexiglas stator disk
1	5/16", 7/8" long threaded rod extender
1	5/16", 1-½" long bolt
10	5/16" flat washers
3	1" flat washers

All of the above is available for \$79 + shipping from *Nuts & Volts* at <http://store.nutsvolts.com>. The Lomanco Whirlybird model B1B-12 roof ventilator can be purchased at Home Depot or other home improvement outlets. Use no substitutions.





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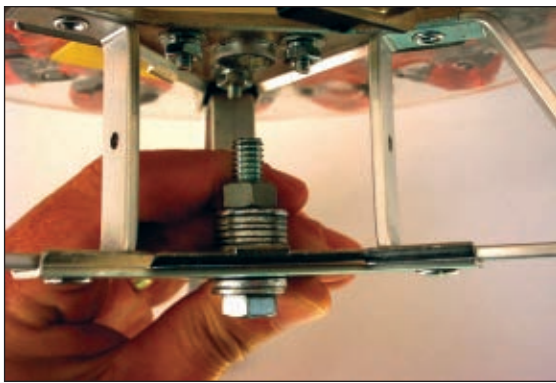


Figure 16 – Assembling the Stator and Rotor Together.

give the turbine a good spin. You should get a voltage reading between one and four volts AC, depending on how fast you spin the turbine (**Figure 17**). Repeat the test for screw terminals 3 and 4, and 5 and 6. If you get the same general voltage reading on all three screw terminal pairs, this indicates

that the turbine is working correctly. You have successfully completed the wind turbine assembly portion of the project, which is all I have space for this time.

First Tests

Before going further, it's time to test the coil connections with a multimeter. Set the multimeter dial to resistance and apply the probes to screw terminals #1 and #2. If all is correct, the reading should be between 25 and 30 ohms. This is the total resistance of the first four coils taken together (in series). If your reading is well above this value, you probably have an open circuit and need to re-check the coil connections as they most likely are not making contact with their mating coils. Re-strip the wires and re-twist them together again. Then check the other two coil arrangements between screw and #6. Repeat the repair procedure if the coil resistance is not within limits.

Next, set the multimeter to AC voltage at a range between zero and five volts and place the meter probes on screw terminals #1 and #2 again;

Figure 17 — Measuring the AC Voltage Output of a Single-Phase.



Wrap Up

In the next article, I'll get into attaching the Whirlybird to the BS2 and 28X2 setups to do some very interesting experiments. If you can't wait until then, you can visit www.learnonline.com → Experimenter Kits → BS2 or 28X2 → Wind, and click on the wind experiments. Next time, I'll also go into more theory about wind speed and how it affects power output, especially three-phase full-wave rectification which I didn't explain in any detail yet. I'll even show you how to slow down and stop a rotating wind turbine under the full force of the wind without using a mechanical break or ripping your fingers off in the process. In the meantime, conserve energy and "stay green." **NV**

Helpful Websites

<http://electrical-science.blogspot.com/2009/01/magnetism.html>

Good source of theory on magnetism and electricity generation.

www.windstuffnow.com

Lots of good equations and DIY wind turbines.

www.otherpower.com

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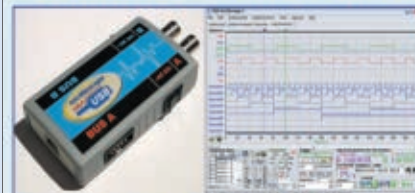
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Serial Communications

Part 1 - Graphical User Interfaces

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by Joe Pardue

Recap

Last month, we finished with our introduction to the Arduino Projects Kit (available from *Nuts & Volts* and Smiley Micros) and used all the parts to do some interesting things. This month, we will start to look a bit deeper into communicating between the Arduino and a PC. We will begin a three-part series about serial communications between a PC and a microcontroller. In the first part, we will learn a bit about the virtual serial port used in the Arduino and introduce writing programs on the PC using the free Microsoft C# and Visual Basic Express .NET applications. We'll use this to build Graphical User Interfaces (GUIs). Next month, we will apply this knowledge to build a Simple Terminal program. In the third part, we will build a GUI for an Arduino VoltMeter.

Virtual Serial Port Introduction

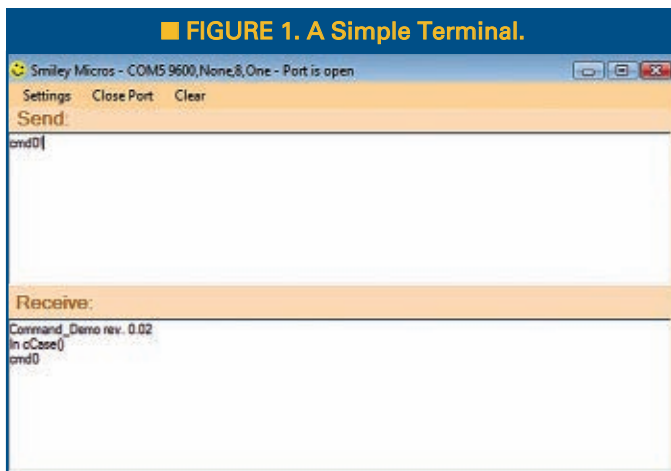
Why Imitate a PC Serial Port with USB?

In the old days, the PC serial port had a Windows® driver and hardware link based on the RS-232 electrical specification, and used a DB-9 connector and a UART (Universal Asynchronous Receiver Transmitter). It wasn't

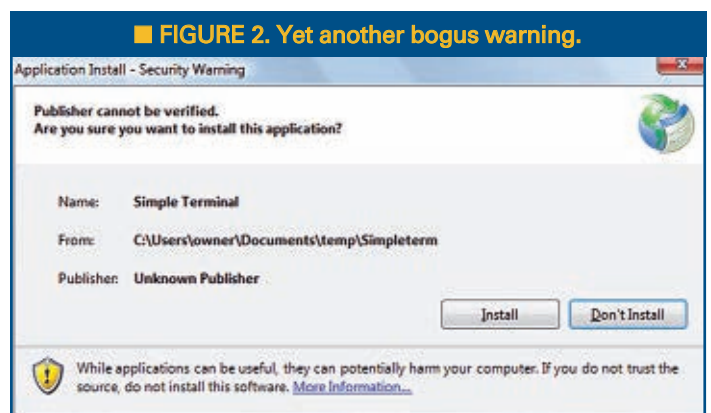
exactly simple for a novice PC user to hook up a serial link since it required the user to select software interrupts and set hardware jumpers – something you and I as certifiable nerds like to do, but something that normal people hate and tend to mess up. These and other complications led to the development of the Plug and Play initiative (more commonly and correctly known as Plug and Pray). One part of all this was to replace the serial port with USB to help simplify things. This helped the user, but made the developer's life much more complicated. Lots of perfectly good serial devices and a couple of decades of knowledge of how to do robust RS-232 style serial communications between PCs and external serial devices were made obsolete by USB.

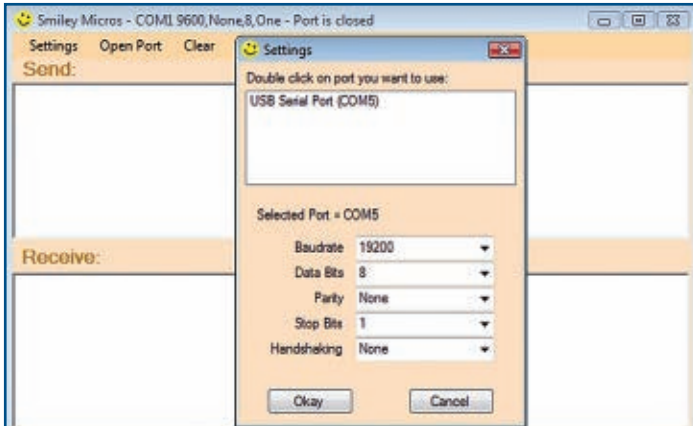
I've read the USB specification, and I'm here to testify (brother, amen) that the old ComPort/UART/RS-232 was a piece of cake compared to USB. I worked with USB when it first came out and my brain is definitely worse for the wear. Fortunately, some really smart people created a transitional concept: to have an old fashioned RS-232 style serial port that runs over USB. The FTDI folks call this a Virtual Communications Port (VCP). It allows legacy applications to continue to use the old microcontroller code and the Windows COM port software with the USB part. This is all tidily bound up in a black box that the developer doesn't have to open. These transitional devices

■ FIGURE 1. A Simple Terminal.



■ FIGURE 2. Yet another bogus warning.





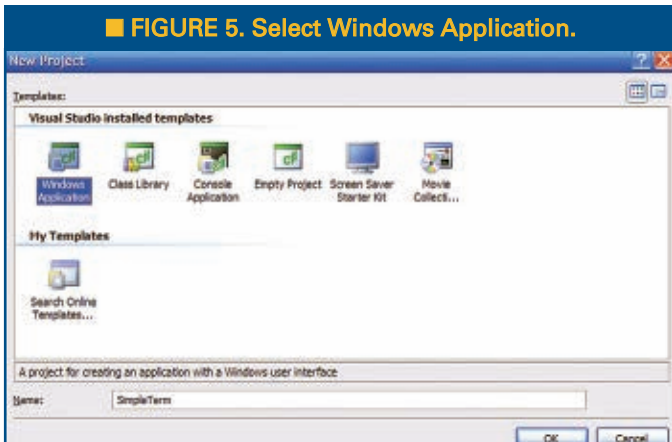
■ FIGURE 3. Settings.

give us the best of both worlds: the ease of using the serial (COM) port and the ubiquity of using USB. The developer has the option of adding RS-232 level converters to completely emulate the old way of doing things, or leaving the level converters off and outputting voltage levels directly compatible with a microcontroller's UART. The latter is exactly what the Arduino does to allow serial communications with a PC.

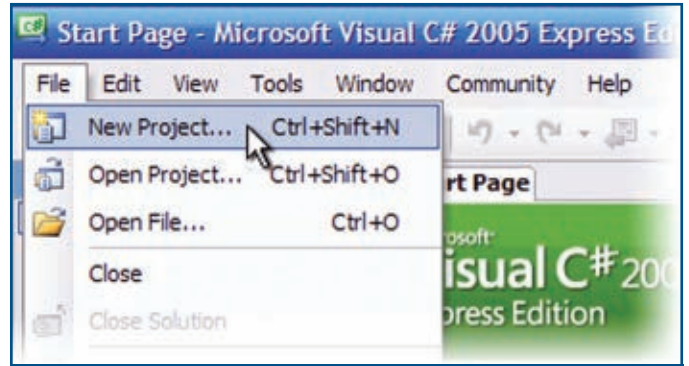
The FTDI chip (FT232R) used on the Arduino is the same as that used on the BBUSB that was discussed in detail in the article “The Serial Port is Dead, Long Live the Serial Port” by yours truly in the June ‘08 issue of *Nuts & Volts*. You can also get the book *Virtual Serial Programming Cookbook* (also by yours truly) and an associated projects kit from either *Nuts & Volts* or Smiley Micros. Much of the information in this article on using C# and VB for serial communications is derived from that book.

Why Communicate With a PC?

A microcontroller is used to control something. The something could be the ignition timing on your car, the water temperature in your washing machine, the obnoxious tune (that you think is cute) on your cell phone, etc., etc., etc. The word 'ubiquitous' seems almost invented to describe the current uses of microcontrollers;



■ **FIGURE 5. Select Windows Application.**



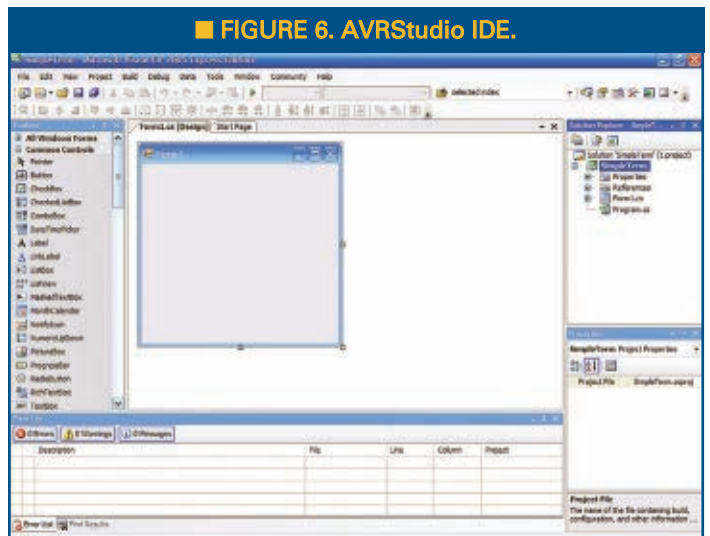
■ FIGURE 4. New Project.

they really are everywhere.

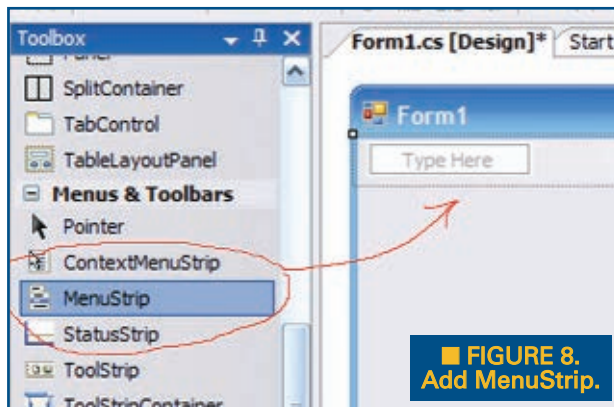
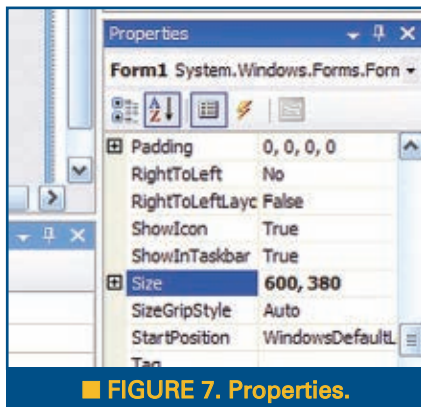
Most often, the microcontroller knows how to do its job and doesn't need any advice from you. If it does deign to accept suggestions, you usually give them via a button (snooze alarm) or touch pad (microwave oven). Some of us — mostly students, hobbyists, and developers — want to spend a lot of time in conversation with a microcontroller, however. This may be because we want to learn how it works; get it to follow complex commands that aren't easy to give with buttons; or because we are designing a complex system and we need direct access to the micro's brains while we are figuring out why things aren't working like they are supposed to. If you are one of these folks, then you might see the benefit of being able to use the vast resources of a PC to talk to your microcontroller. We will look at some things to help you to do this.

Why Use C# and Visual Basic Express .NET?

One good reason for selecting either language in Express .NET is because both are free. (You like free, don't you?) I decided to present the software in both C# and Visual Basic Express.NET because there are lots of folks who program in one language and think the other language is the vile realm of hell-bound heretics. However, the concepts are the same no matter what language is



■ FIGURE 6. AVRStudio IDE.



program. Before we write it, let's play with the finished version to get some insight into where we are going once we actually write the code.

Running the Simple Terminal

The Simple Terminal is available in two forms: first is a publish version that allows you to install and

being used (religious wars aside). Examples are done in both languages with the C# example shown here, and the Visual Basic example included in the Workshop18.zip. Just skip over the language you don't like.

You will find a treasure trove of free tools and learning materials at www.microsoft.com/express/. If you are entirely new at programming GUIs (pronounced gooey) on Windows, then I'd suggest that you use C#, since it's similar to C and is most likely the language you will choose for the other side of the cable – the microcontroller. If you are already a Basic fan or have used VB on a PC, then you will probably want to use the Visual Basic Express. Be prepared for a lot of culture shock, however.

The IDE shown in many of the illustrations here will be for C#; the Visual Basic IDE is virtually identical, so it shouldn't be difficult to transpose the concepts.

As I stated before, the Microsoft learning resources are really great and free. For our purposes, you don't need to view all the lessons, just the introductory materials, plus the parts on forms and common controls. Keep in mind the ultimate goal: We are learning to use tools that will allow us to build GUIs on a PC that we can use to communicate with microcontrollers connected to either a real serial port or a USB virtual serial port.

Once you're comfortable with building simple forms with textboxes and buttons, you are ready to look at the Simple Terminal software source code. Pay careful attention as we go through the steps to create this

run the program on your PC; the second version is the source code that loads in Visual Studio Express .NET.

The Workshop18.zip includes:

- ..\Simple Terminal Application
- ..\Arduino Command_Demo
- ..\SimpleTermGUI_C#_Source
- ..\SimpleTermGUI_VB_Source

Unzip it and open the Simple Terminal Application directory; then click on the setup application. You will see the warning shown in **Figure 2**. Click Install if you are using Vista (cuss it out if it asks you if you are sure). It should open and look like **Figure 1**, except that the text boxes should be empty.

Click on the 'Settings' menu item. In the Settings dialog, click the COM port connected to the Arduino as shown in **Figure 3**. In my case, the only port available is COM5. Your Arduino will probably be on a different port, so click on that one. Make sure the serial port you selected shows up in the Serial Port label. If you don't click it, then the port defaults to COM1. The Arduino Command_Demo that we will be using has a baudrate set to 19200, which is the default for the Simple Terminal. You should now click 'Okay.'

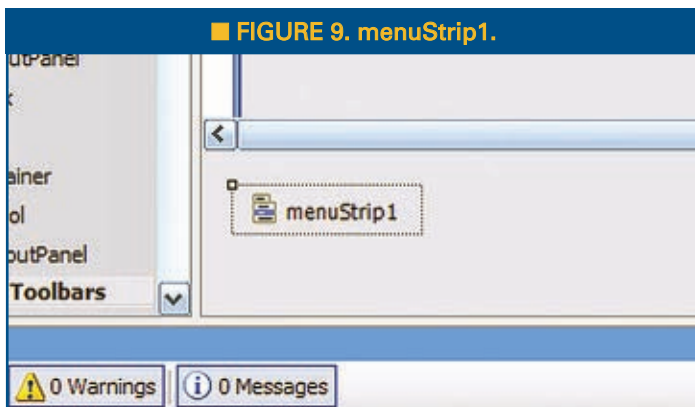
Next, open the Arduino Command_Demo directory on your PC and then upload the Command_Demo program into the Arduino as discussed in earlier workshops (copy/paste/run). Press the reset button on the Arduino and you should see 'Command_Demo rev. 0.02' in the Receive text box. Finally, enter 'cmd0!' in the Send text box and you should see the response in the Receive box as shown in **Figure 1**.

Cool! Now, let's follow a recipe and cook up a Serial Terminal GUI for ourselves, shall we?

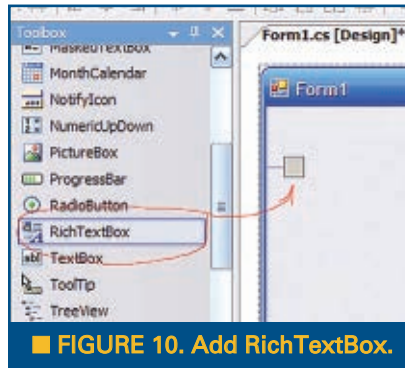
Build a PC Graphical User Interface

The Main Form

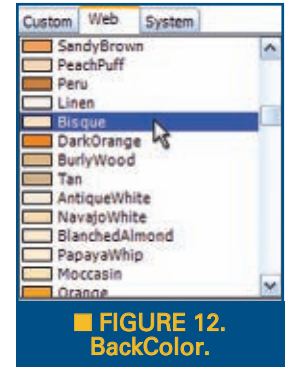
- Open C# or Visual Basic 2008 Express. They are nearly identical so the following introduction to the IDE (though in C# Express) works equally well for either.



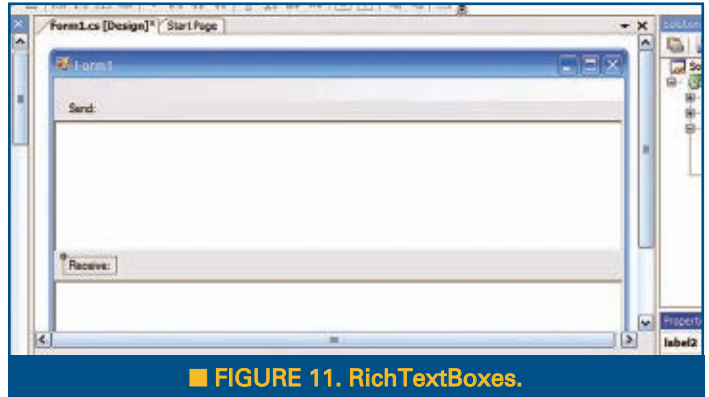
- From the 'File' menu select 'New Project' (**Figure 4**).
- In the 'New Project' form, highlight Windows Application and change the name to Simple Terminal and click the 'OK' button (**Figure 5**).
- The IDE should look like **Figure 6**.
- Take note of the various panels. We will call the central panel the 'Editor Window,' the left panel the 'Toolbox;' the upper right panel the 'Solutions Explorer;' and the lower right panel the 'Properties Window.' In the Properties Window, change the size from 300,300 to 600,380 (**Figure 7**).
- In the Toolbox, click and hold the MenuStrip, then drag and drop it on Form1 (**Figure 8**).
- Note that the specific instance of menuStrip1 of the class MenuStrip appears below Form1 in the Edit Window (**Figure 9**).
- In the Toolbox, click and hold the RichTextBox. Then drag and drop it on Form1 (**Figure 10**).
- In the Properties Window, change the richTextBox size from 100,96 to 590,136.
- In the Properties Window, change the richTextBox location to 0,44. (You may be wondering where I'm getting these funky dimensions. Well, I just used the cursor to size the items until they looked right – which you can also do – but if you want to get your Simple Terminal to look exactly like mine, you'll need to hand-input the dimensions.)
- Add another richTextBox (same size) – richTextBox2 – below the first. Change the location to 0,209.
- From the ToolBox, select 'Label,' and drag and drop it between the MenuStrip and richTextBox1.
- In the Properties Window, change 'Text' from label1 to Send:.
- Select a second label and drop it between richTextBox1 and richTextBox2. Change the Text from label2 to Receive:.
- The color scheme is boring! Plain old gray just won't cut it. Let's tart this up a bit (**Figure 11**).
- Select Form1 and in the Properties Window, select



■ **FIGURE 10. Add RichTextBox.**



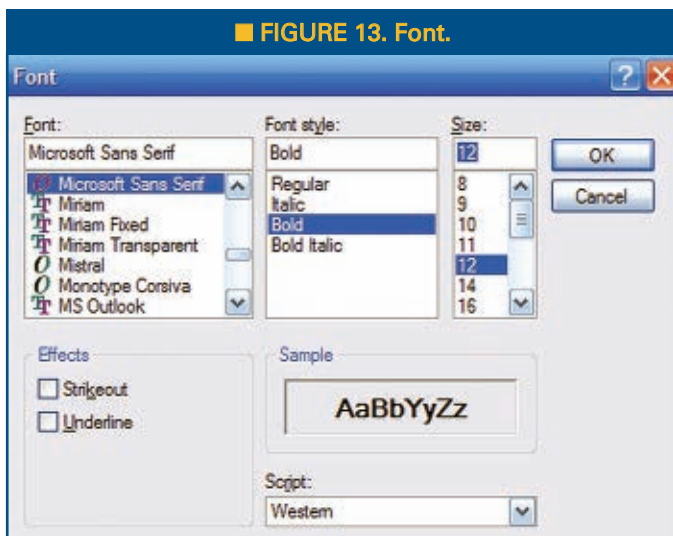
■ **FIGURE 12. BackColor.**



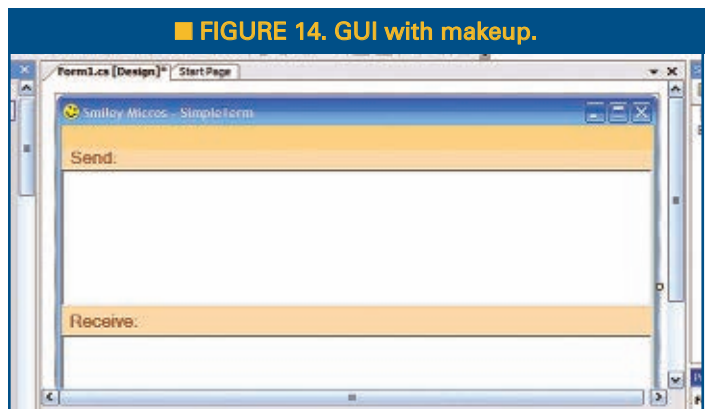
■ **FIGURE 11. RichTextBoxes.**

BackColor and click the down arrow to show the color menu. Select Bisque.

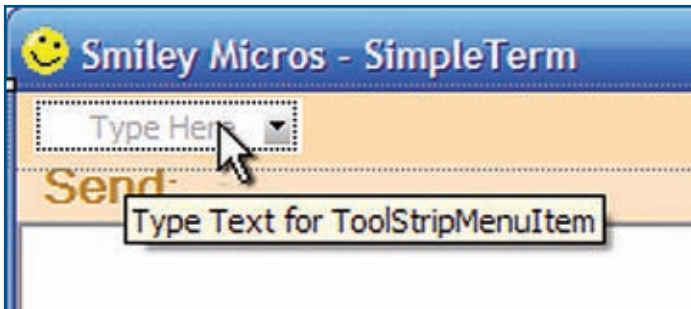
- In the Edit Window, select the menuStrip1 and in the Properties Window, select 'BackColor.' Choose NavajoWhite (**Figure 12**).
- Select label1 and in the Properties Window, choose Font. Change the Font Style to Bold and the Size to 12 (**Figure 13**).
- In the Properties Window for label1, select ForeColor and change to DarkGoldenrod.
- Select Form1 and in the Properties Window, change text to 'Smiley Micros – Simple Terminal' or some other less commercial name if you prefer.
- While still in the Form1 Properties Window, select Icon and then select 'Smiley.ico' (located in the \Software\Graphics\ directory).
- You've got to admit, a little makeup helps (**Figure 14**).



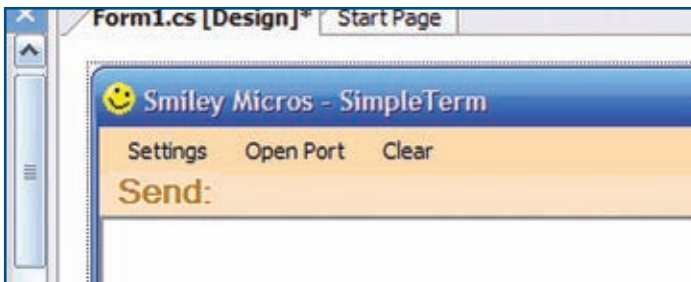
■ **FIGURE 13. Font.**



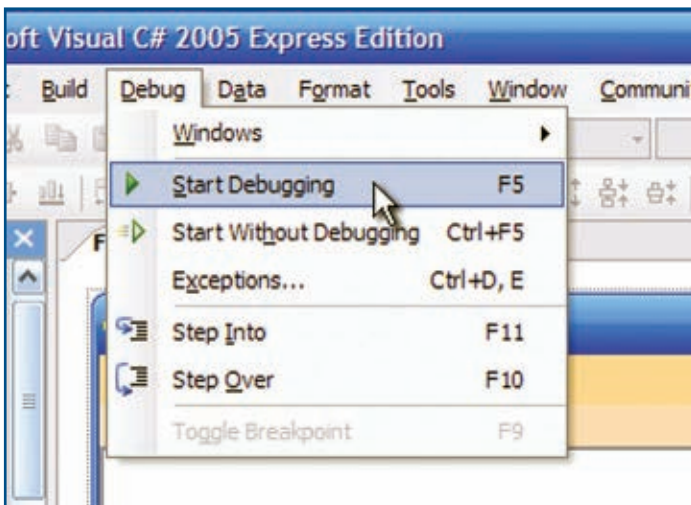
■ **FIGURE 14. GUI with makeup.**



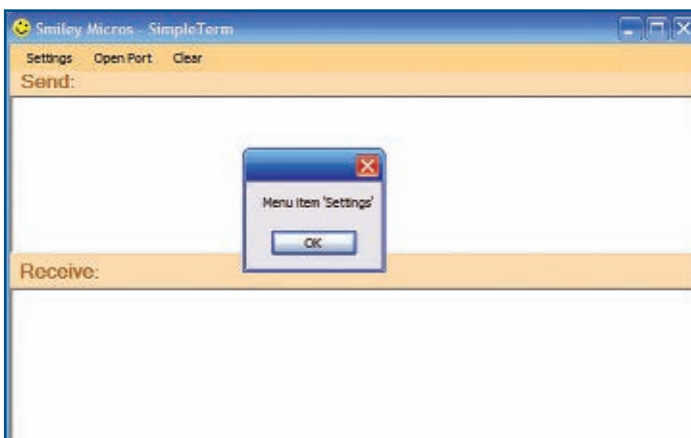
■ FIGURE 15. Add menu item.



■ FIGURE 16. Menu items.



■ FIGURE 17. Start debugging.



■ FIGURE 18. Click the Settings menu item.

- Select the MenuStrip and highlight the 'Type Here' box (**Figure 15**).
- Type Settings.
- Move your cursor to the next menu position to the right; type Open Port.
- In the next right, type Clear (**Figure 16**).
- Now, SAVE YOUR WORK! – Do this every time you have done enough work that you'd feel bad if you lost it.
- In the Express IDE menus, select Debug and click Start Debugging (**Figure 17**).

Whoa, look at that! You didn't write a word of software and yet you just created a GUI for a serial terminal! Click the little X in the upper right to close the debug form.

Making the Simple Terminal GUI Do Something

Add Functionality to the Menu Items

This is what we see in the C# Edit Window:

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;

namespace WindowsApplication2
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
        }
    }
}
```

- In the IDE, double click on the menuStrip1 Settings button.
- In the Edit Window, click the 'Form1.cs [Design]' tab to view the Design Editor panel. Now click the 'Open Port' menu item.
- Repeat for the 'Clear' menu item.
- In the Form1.cs code window, you'll see that the IDE has created three functions that will be run when you click the menu item.
- In C#, add the following text to each:

```
private void settingsToolStripMenuItem_Click(object sender, EventArgs e)
{
    MessageBox.Show("Menu item 'Settings'");
}

private void openPortToolStripMenuItem_Click(object sender, EventArgs e)
{
    MessageBox.Show("Menu item 'Open Port'");
}

private void clearToolStripMenuItem_Click(object sender, EventArgs e)
```

```
{
    MessageBox.Show("Menu item
    'Clear'");
}
```

- Run the program in debug mode again (Debug/Start Debugging).
- Click the 'Settings' menu item.
- Likewise, test the 'Open Port' and 'Clear' menu items.
- Close the debug form.
- Select Form1.cs and change the Clear menu function to:

```
private void clearToolStripMenuItem_
Click(object sender, EventArgs e)
{
    richTextBox1.Text = "";
    richTextBox2.Text = "";
}
```

- This will cause the text in the rich text boxes to be cleared.
- Run the program in Debug mode and type some text in each richTextBox. Then click the Clear menu item to see it work.
- The source code is in the \Software\Chapter 4 - Simple Terminal GUI \ directory.

If you are anxious to get a jump-start on next month's article, you can get the details for building the Simple

Terminal in the first six chapters of 'Virtual Serial Port Cookbook' from www.smileymicros.com which are available for free, or if you find yourself interested in the FTDI FT232R chip used in the Arduino for serial communications, then you can purchase the book and a projects kit from *Nuts & Volts*. I will start a thread on www.avrfreaks.net titled 'Smiley's Simple Terminal' and I'll try to check by several times a week to see if there are any questions.

Wrap-Up

In this workshop, we went through the Microsoft tutorials and learned just enough to be dangerous. We also built the GUI for a Simple Terminal. In the next workshop, we will build a dialog form (Settings) to get data from the user for selecting a serial port, and set up the UART. We will then learn to use the Serial Port Class, and finally we will build an Arduino voltmeter that displays the output on a PC. **NV**



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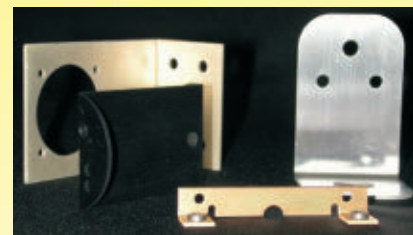
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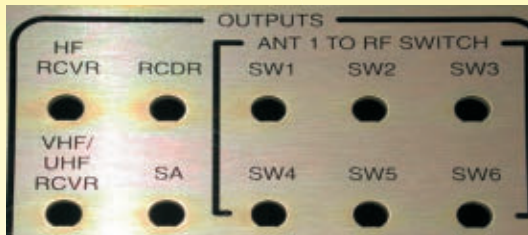
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SUPERPIC TO THE 32-BIT RESCUE!

It pays to attend the annual Microchip MASTERS Conference. While I was there, rumors were as thick as flies at a hog roast. Engineers were talking about a new 32-bit PIC that would include multiple UARTs, CAN ports, a 10/100 Ethernet MAC, a bunch of SPI modules, and loads of I²C interfaces with plenty of I/O pins to spare. My first thought was a new SuperPIC is born. Naturally, the new 80 MHz SuperPIC would also command the USB world with an on-chip, 2.0-compliant, full-speed and OTG (On-The-Go) USB controller.

As it turned out, the rumors were justified. I happen to have a couple of the brand new PIC32MX795F512L SuperPICs on the bench. I also have the latest version of the MPLAB C32 Compiler for PIC32 microcontrollers which supports all of the new SuperPIC features. I don't know about you, but having all of this development stuff in front of me says "Build something!"

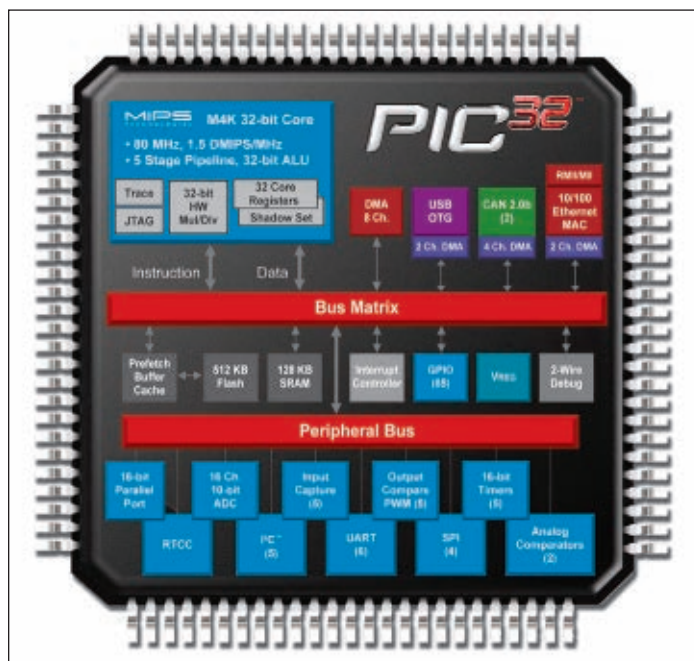
CLEARING THE AIR

Yes, I did promise to do some 16-bit USB work this month. However, I wanted to show you the new PIC32 as quickly as possible. So, instead we're going to do some 32-bit Design Cycle USB work. Don't worry. We'll still take a crack at implementing a HID-class device on the 16-bit PIC24FJ256GB110 at a later time.

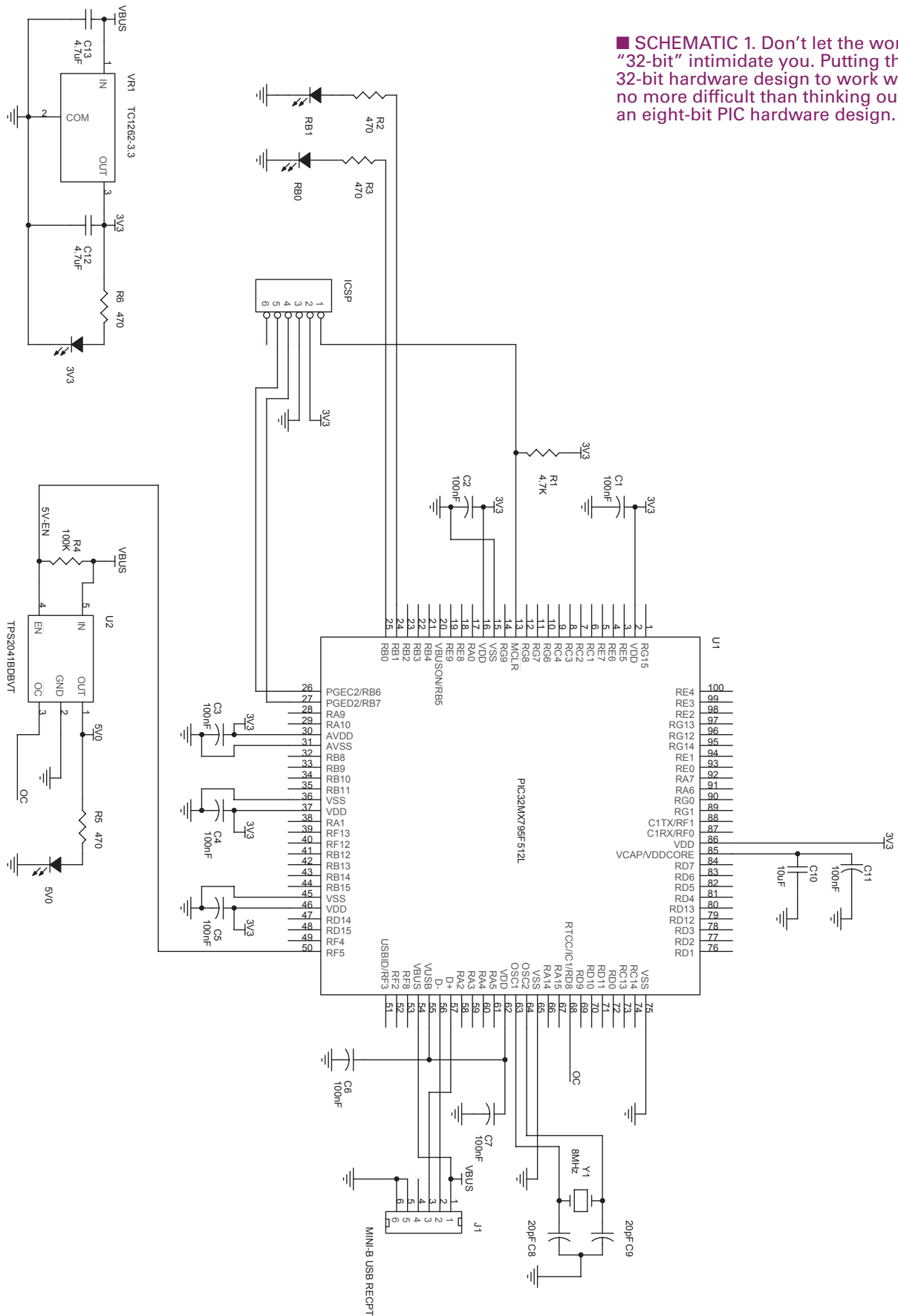
Before we start designing our 32-bit circuitry, let's verify the rumors. The PIC32MX795F512L does indeed support multiple UARTs; six to be exact. As for multiple CAN modules, there are two portals available which, by the way, can talk to each other. Five I²C interfaces are pinned out on the PIC32 which beats out the number of pinned out SPI modules by one. Bear in mind that due to pin multiplexing, you may not be able to use all of the peripherals I've just outlined at the same time. For instance, I²C module 1, SPI module 1, and UART 1 share some of the same pins. However, with careful pin planning, you can usually gain access to all of the targeted modules your design requires.

Like the PIC32MX460F512L we're working with over in *SERVO Magazine* this month, the PIC32MX795F512L can clock on its internal 8 MHz and 32 kHz oscillators. While having an internal 8 MHz oscillator has many advantages, the internal 8 MHz has limited use if we enable and use the PIC32's USB engine. So, we'll see later that an 8 MHz external crystal is all we need to PLL our way to an 80 MHz clock speed with an active USB interface. While we're talking clocks, if you are into microcontroller timers like I am, the PIC32's five 16-bit timer/counters are great to have at our disposal. The ability to morph a pair of 16-bit timers into a 32-bit timer

■ **FIGURE 1.** Now you can see for yourself why I call the PIC32MX795F512L a SuperPIC. I haven't been this excited about a new PIC since the PIC16F84. With the advent of the PIC32MX795F512L, we have the ability to mix and match CAN, Ethernet, I²C, SPI, and RS-232 interfaces.



■ **SCHEMATIC 1.** Don't let the word "32-bit" intimidate you. Putting this 32-bit hardware design to work was no more difficult than thinking out an eight-bit PIC hardware design.



is cherries on the cheesecake.

Figure 1 ties up all of the loose ends as far as what's inside the new PIC32MX795F512L. Now we can match up USB with Ethernet, or CAN with USB, or SPI with USB, just to point out a few of the possible combinations. (I think you get the idea.) So, let's go do what we came here to do. Let's build up some PIC32 hardware and teach it to speak HID.

THE HARDWARE DESIGN

The PIC32MX795F512L hardware design I'm offering to you is best understood by breaking down the complete design shown in **Schematic 1** into smaller subsystems. So, let's walk our way around the beginning with the first populated pin.

The PIC32 is a 100-pin device with pins spaced at 0.40 mm. Of the 100 pins, 14 are designated as power entry or ground points. Capacitors C1, C2, C3, C4, C5, C6, C7, and C11 are 100 nF power supply bypass components. To keep the power supply bypass capacitors as close as possible to their power pins, I chose to populate these capacitors in 0603 packages.

The PIC32MX795F512L can operate with a supply voltage as low as 2.3 VDC or as high as 3.6 VDC. As you can see in **Schematic 1**, our design is powered by a 3.3 VDC supply. Thus, the I/O logic levels will be based on this as the peripheral I/O subsystem is powered from the power entry and ground pins. It's a different story when we traverse around to pin 84.

The PIC's CPU core requires 1.8 VDC. To this end, its designers included an internal 1.8 VDC voltage regulator which requires the use of a filter capacitor as shown in the **schematic**. C10 is a low-ESR 10 μF @ 6.3 WV ceramic capacitor in a 0805 SMT package. The value and voltage rating of C10 is not something that I pulled out of the air. The PIC32 datasheet states that the 1.8 volt voltage regulator filter capacitor must be a low-ESR type that is rated at a minimum of 6.3 working volts. So, that's that.

If you're wondering where the power supply bypass capacitor is for pin 85, it is tied to 3.3 VDC for proper operation. (Pin 85 was the ENVREG pin.) I didn't find any bypass capacitor attached to pin 85 in the official Microchip documentation. So, I took the monkey see, monkey do stance.

It took a while, but now I'm very comfortable with Microchip supplying the microcontrollers and the peripheral devices in my circuits. Those 0603 SMT power supply bypass capacitors in our PIC32MX795F512L design are working behind a regulated power supply voltage under the control of a TC1262 voltage regulator. The TC1262's 5.0 volt input voltage is derived from the VBUS pin of the host USB portal. The TC1262 is a 500 mA LDO (Low Dropout) voltage regulator that only requires a 1 μF low-ESR filter capacitor at its input and output pins for stability. In most cases, up to a point, more is better when it comes to voltage regulator support capacitors. After

thorough study, I didn't find any official designs that used the minimum TC1262 capacitor configuration. I did find a reference design that used 4.7 μF filter/stability capacitors. So, once again I swung with the monkeys.

The next dedicated connection is found at pin 13 which happens to be the MCLR pin. Note the absence of all of the normal ICSP resistors and capacitors I normally place around the MCLR pin. All the PIC MCLR pin requires is a 4,700 Ω pullup resistor. In the case of the PIC32MX795F512L, Microchip tells us to avoid placing the legacy resistor/capacitor reset componentry on the MCLR pin as the capacitance may interfere with the programming and debugging processes. If an MCLR reset capacitor is required, the design should allow the reset capacitor to be jumpered in and out of the MCLR circuit.

The pair of LEDs attached to the RB0 and RB1 I/O pins are intended to be used as USB state indicators. However, the programmer can commandeer them for other purposes as he or she sees fit.

The PIC32MX795F512L pins out two sets of ICSP clock and data pins: PGEC1-PGED1 and PGEC2-PGED2. The set of ICSP clock and data pins that become active is determined by configuration bits, which are set by the PIC32 programmer. Here's how PGEC2 and PGED2 were selected:

```
#pragma config ICESEL    = ICS_PGx2
// ICE/ICD Comm Channel Select
```

Moving forward from ICSP pins 26 and 27, we encounter the trio of power inputs before landing on pin 50 which is configured as an output I/O pin. If you take a look at the code, you'll see that this pin only goes logically low after the USB connection is validated and activated. When pin 50 goes logically low, the TPS2041B's EN pin is driven low and the TPS2041B switches +5.0 VDC into the 5.0 volt area of the four-layer printed circuit board's Power plane.

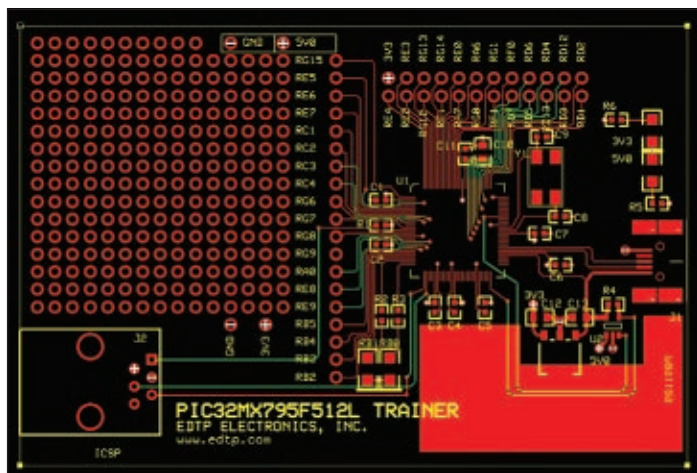
SOURCES

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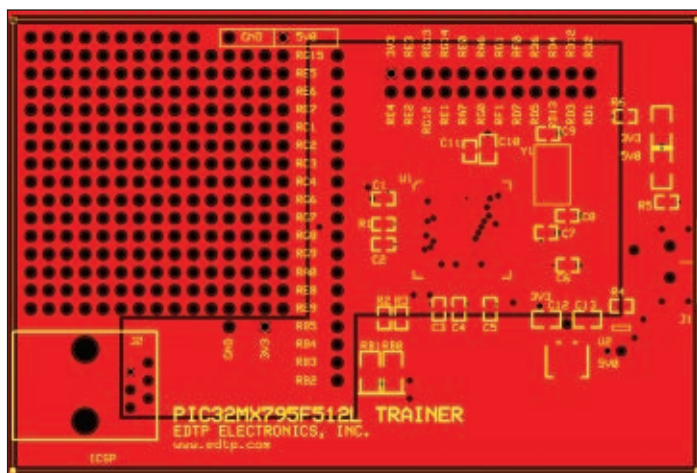


■ **SCREENSHOT 1.** This is an ExpressPCB boilerplate PIC32MX795F512L PCB design that you can use to quick-start your own project.

The Texas Instruments TPS2041B is a current-limited power distribution MOSFET switch that can handle a continuous current load of 500 mA @ 2.7 to 5.5 volts. In addition to providing the services of a 70 mΩ high-side MOSFET switch, the TPS2041B does all kinds of back flips to keep the circuitry under its charge so it's protected from shorts and overcurrent events.

The idea behind including the TPS2041B entails the possibility of having to power a companion 5.0 volt device from the USB VBUS power supply. We must request enough current from the USB VBUS power supply to cover the 5.0 volt device's current draw plus the PIC32MX795F512L's current requirements. Once the USB host grants the current request, we can switch in the 5.0 volt power and thus feed the external 5.0 volt device that is part of our design. You saw us perform a similar action with the low pin count USB Development Kit/Ethernet MINI combination except an MCP1825 3.3 volt voltage

■ **SCREENSHOT 2.** This is the Power plane of an ExpressPCB four-layer PCB. Note that I have partitioned the Power plane into a 3.3 volt area and a 5.0 volt area. The Ground plane can also be partitioned. However, we have no need for a partitioned Ground plane in the PIC32MX795F512L TRAINER design.



regulator was switched on by the PIC instead of a MOSFET switch (like the TPS2041B). The 5V0 LED is used as an indicator to signal that the USB host has granted our current supply request and five volts is available to our circuitry. The 3V3 LED on the output of the 3.3 volt voltage regulator illuminates when VBUS voltage is presented to the TC1262 voltage regulator's input and no over-current events are present on the 3.3 volt power bus.

Leaving the RF5/5V-EN pin, our next stop is the USB I/O area. The VBUS pin is a USB bus power monitor pin while VUSB is the power input for the PIC32MX795F512L's USB transceiver. The USB data lines are pinned as D+ and D-. There is nothing remarkable about the PIC32's USB interface when compared to other USB-capable PICs. However, keep in mind that the PIC32MX795F512L has the physical and logical capability to act as a USB host.

As I mentioned earlier, we will employ the services of an external 8 MHz crystal. Using an external crystal instead of the PIC's internal 8 MHz oscillator allows us to feed the 8 MHz clock signal through the internal USB PLL to obtain the desired USB clock signal. The 8 MHz internal oscillator does not utilize the USB PLL and thus cannot supply the required 48 MHz USB clock. The 8 MHz internal oscillator is used by the USB engine to detect USB activity in low power modes and is intended to allow the USB module to detect and report a USB wake-up. To sum it up, the PIC32MX795F512L's USB engine must run with a 48 MHz clock, which is derived from its primary oscillator and USB PLL.

Our final I/O pin of interest is an input that detects an over-current condition reported by the TPS2041B. When the current draw is excessive or a short circuit occurs on the 5.0 volt power bus, the TPS2041B shifts into constant current mode and pulls the OC line logically low. We can use the TPS2041B's OC input to trigger an over-current handler in the PIC32 code. A typical over-current reaction would be to deactivate the 5.0 volt power supply by driving the 5V-EN line (RF5) logically high, disabling the 5V0 voltage output of the TPS2041B.

The I/O pins we didn't discuss assist the dedicated pins in releasing the logical magic that lies within the silicon of the PIC32MX795F512L. However, we can't call upon the PIC's magical powers without placing it on a magic carpet.

THE PIC32MX795F512L TRAINER

Thanks to ExpressPCB and their new line of inexpensive, four-layer printed circuit boards (PCBs), I was able to easily design and fabricate a suitable magic carpet for our SuperPIC. My four-layer copper-coated fiberglass slab design is captured in **Screenshot 1**. This design is aimed at developing USB HID-class devices. So, I did not attempt to bring out all of the unused I/O pins to header points.

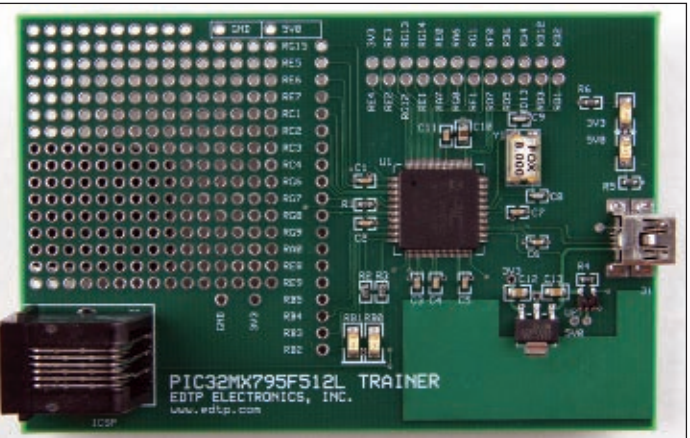
The PIC32MX795F512L TRAINER's componentry is electrically connected just as it is laid out in **Schematic 1**.

So, let's explore the other aspects of the TRAINER PCB. **Screenshot 2** is a view of the Power plane. If you turn your attention to the lower right of the shot, your eyes will pick up the TC1262 voltage regulator silkscreen legends. Notice that the 3V3 Power plane access hole is inside of the octagonal outline. Everything inside the octagonal fence has direct Power plane access to the 3V3 (3.3 VDC) power source only. Outside of the etched fence, drilling into the Power plane will yield 5V0, or 5.0 VDC power. You can see that the 5V0 Power plane access hole is well outside of the 3V3 octagonal area. Note also that R6 – which is the current-limiting resistor for the 3V3 LED – is dipping into the 3V3 area for power while resistor R5 drills its power source hole solidly in the 5V0 area of the Power plane. The Ground plane of the TRAINER is also capable of being partitioned. We don't have a need to isolate the 3V3 and 5V0 ground planes. So, there are no Ground plane partitions in the PCB design. A fully assembled TRAINER based on **Screenshot 1** is saying cheese in **Photo 1**.

CODING A PIC32MX795F512L HID-CLASS DEVICE

Let's begin our coding work by establishing the PIC32MX795F512L operating parameters via the configuration fuses:

```
#pragma config UPLLEN    = ON
// USB PLL Enabled
#pragma config FPLLMUL   = MUL_20
// PLL Multiplier
#pragma config UPLLIDIV  = DIV_2
// USB PLL Input Divider
#pragma config FPLLIDIV  = DIV_2
// PLL Input Divider
#pragma config FPLLODIV  = DIV_1
// PLL Output Divider
```



■ **PHOTO 1.** If you don't require the CAN and Ethernet features of the PIC32MX795F512L, your hardware design will be very close if not identical to this one.

```
#pragma config FBDIV     = DIV_1
// Peripheral Clock divisor
#pragma config FWDTEN    = OFF
// Watchdog Timer
#pragma config WDTPS     = PS1
// Watchdog Timer Postscale
#pragma config FCKSM     = CSDCMD
// Clock Switching & Fail Safe
// Clock Monitor
#pragma config OSCIOFNC  = OFF
// CLK0 Enable
#pragma config POSCMOD   = HS
// Primary Oscillator
#pragma config IESO      = OFF
// Internal/External Switch-over
#pragma config FSOSCEN   = OFF
// Secondary Oscillator Enable
// (KLO was off)
#pragma config FNOSC     = PRIPLL
// Oscillator Selection
#pragma config CP        = OFF
// Code Protect
#pragma config BWP       = OFF
// Boot Flash Write Protect
```

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```
#pragma config PWP          = OFF
// Program Flash Write Protect
#pragma config ICESEL       = ICS_PGx2
// ICE/ICD Comm Channel Select
#pragma config DEBUG        = ON
// Background Debugger Enable
```

The very first line of configuration code enables the USB PLL. That tells us we'll have to use the Primary oscillator and probably its PLL:

```
#pragma config FNOSC        = PRIPLL
// Oscillator Selection
#pragma config POSCMOD      = HS
// Primary Oscillator
```

Yep. Just as we thought. With that, let's work the Primary oscillator and its PLL from input to output. The first configuration fuse setting affecting the PLL input divides the input frequency by two:

```
#pragma config FPLLIDIV    = DIV_2
// PLL Input Divider
```

So, our PLL input frequency is 4 MHz. The next logical configuration fuse setting multiplies the input frequency by 20:

```
#pragma config FPLLMUL     = MUL_20
// PLL Multiplier
```

Thus, our 4 MHz input frequency becomes an 80 MHz clock signal. However, there is one more configuration fuse setting to consider:

```
#pragma config FPLLODIV    = DIV_1
// PLL Output Divider
```

Dividing our 80 MHz CPU clock by one yields an 80 MHz CPU clock signal. With the CPU clock frequency set, let's see if we have configured the USB PLL correctly. We begin by dividing the incoming 8 MHz clock by two:

```
#pragma config FPLLIDIV    = DIV_2
// PLL Input Divider
```

The USB PLL will take the incoming divided clock signal and multiply it by 24. This is written in silicon stone. Now we have a 96 MHz USB clock signal. The PLL x 24 law is backed up by another USB PLL law which divides the 24x clock signal of 96 MHz by two.

We can also determine how the PIC32MX795F512L peripherals are clocked. The peripheral clock (PBCLK) is derived from a postscaler that is receiving its input signal from the CPU clock:

```
#pragma config FPBDIV      = DIV_1
// Peripheral Clock divisor
```

We now know that the PIC32MX795F512L's peripheral I/O subsystem is clocked at 80 MHz. At this point, we can begin to tailor the rest of our HID code. Microchip has just released a new version of the MCHPFSUSB Framework that we will use to create our 32-bit HID-class device. On the host side, we'll create a unique HID command and control application using the Kadronix USB HID API Library and Visual Basic.

We have a bit more to cover than I have pages for this month. So ...

HERE'S THE PLAN

Next time, we'll assemble and load our HID code into the TRAINER's PIC32MX795F512L. Once we succeed in getting the TRAINER to connect to a PC host, we will assemble some garage-brewed HID application code on the PC side that will move data and commands back and forth between the TRAINER and the PC host.

Meanwhile, you have a PIC32 hardware design to keep you company. I'll provide PCB and component support for the TRAINER by way of the EDTP Electronics website for those of you that want to build up your own hardware. I'll also post the ExpressPCB PCB file on the Nuts & Volts website.

We aren't done with the PIC32MX795F512L yet. However, you know enough about it to add it to your Design Cycle. **NV**

■ Fred Eady can be contacted via email at fred@edtp.com and the EDTP Electronics website at www.edtp.com.

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■ BY L. PAUL VERHAGE

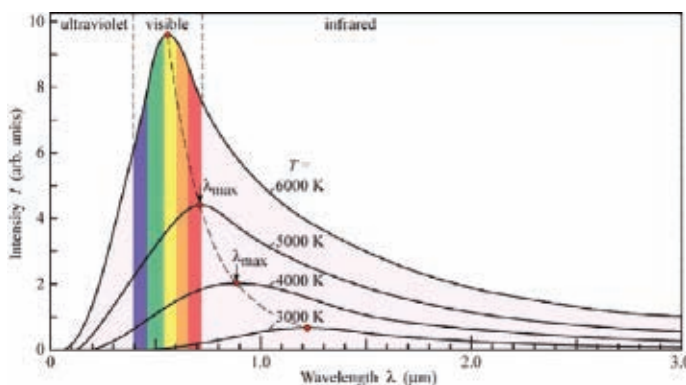
A NEAR SPACE INFRARED TELESCOPE

Space is cold, but thanks to the Earth's thick blanket of air, we're warmer than space — even at night. Parallax has made available an inexpensive infrared thermometer that makes it possible to measure the temperature of an object just by looking at it. In this month's article, I'd like to share how I used this thermometer to design a simple infrared near space telescope that measures the temperature of the sky during a near space mission.



INFRARED THERMOMETERS

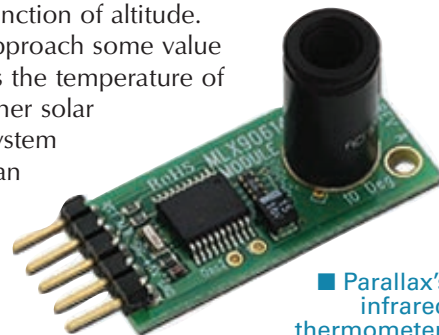
Objects emit more radiation as they grow hotter (in accordance with Planck's and Stephan-Boltzmann's Laws). Not only do they emit more radiation when they're hotter, but the frequency of their peak radiation also increases (in accordance with Wein's Law). You've seen this effect if you've ever watched a blacksmith heat a slab of iron from dull red to bright yellow.



■ This graph illustrates how the amount of radiation an object emits (the area under each curve) increases as it gets hotter. Notice also how the peak wavelength of each curve is getting smaller (this is the same thing as saying its peak frequency gets larger).

The infrared thermometer takes advantage of this fact to measure the temperature of an object without making physical contact. Infrared thermometers are popular in industry where they can measure the temperature of molten steel without workers getting too close to the furnace. Hospitals also use them to measure a patient's temperature via his or her ear. (How cool is it that you can measure the temperature of a distant object this way?!)

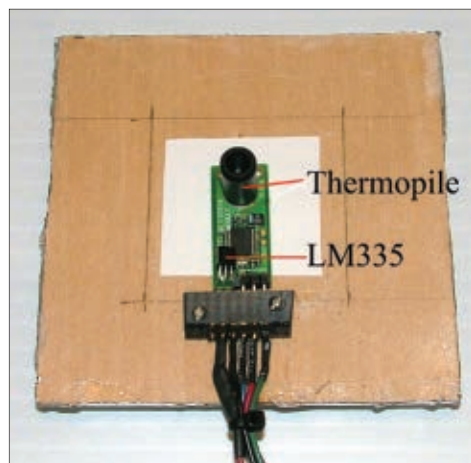
Since the sky grows darker in near space, I wondered if I could detect a change in the sky's temperature as a function of altitude. Perhaps it would approach some value that I could claim is the temperature of space within the inner solar system (our solar system appears warmer than the deep universe because the sun's light reflects off and warms dust and gas). I decided I would try to design an infrared thermometer experiment after I ran across a module (item 28042) while browsing the Parallax website (www.parallax.com). I call the device a near space infrared telescope.



■ Parallax's infrared thermometer. I programmed mine to produce temperature reports on a regular basis.

Parallax has coupled a Melexis MLX90614 module with a SX20 micro to create a smart, no contact, infrared thermometer. The module's SIP (single inline pin) form factor and smart interface makes it easy to interface to a near space flight computer. The SIP module has five pins, but only three (signal, power, and ground) are needed for the near space infrared telescope. Rather than permanently soldering the SIP module to a wiring harness, I made a socket from a double row header that I had lying around. Since only three wires are needed to collect data from the infrared thermometer, there are three wires (color coded so I'll remember their functions) soldered to the pins of the header. For protection from accidental shorts, the soldered connections between the header pins and wires are covered in heat shrink tubing.

To ensure the validity of the telescope's data, I needed to determine if the local air temperature is influencing the module's readings. It's not the end of the world if it does, as I can remove this effect when I process its data after a mission. Therefore, I needed a separate method to monitor the temperature of the infrared thermometer module. An extremely easy way to do this is to place an LM335 temperature sensor next to the module. The LM335 plugs into the same double row header as the infrared thermometer so all I needed to do is solder a 1K resistor and three additional wires to the appropriate header pins. The header for the infrared thermometer and LM335 was then bolted to the back plate of the near space infrared telescope as you see in the **photo**.



■ A thin sheet of white plastic is placed behind the infrared thermometer to help keep the back of the sensor cooler by reflecting undesired incident radiation.

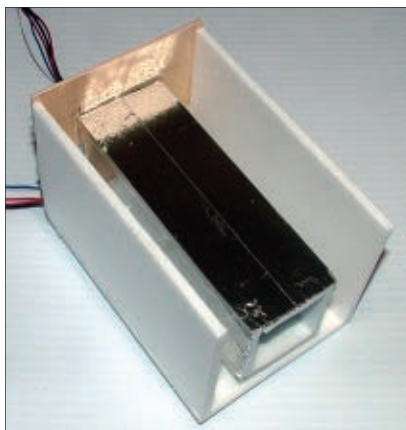
A TUBE WITHIN A TUBE

The infrared thermometer has a limited field of view and a filter that makes it solar blind (it can't see the sun or measure its temperature). That said, I still wanted to restrict the ability of outside radiation sources from affecting its readings. I assembled a tube of thin Styrofoam (5 mm thick Cellfoam 88) and wrapped it in a layer of aluminum duct tape. The tube is glued together

with hot glue and attaches to the back plate with additional hot glue. That's the first barrier, as any light that manages to shine on the side of this inner tube should reflect away from the sensor. Moreover, whatever light does manage to get through the aluminum should have a difficult time warming the interior surface of the inner tube because of the Styrofoam insulation.

A second, larger diameter tube surrounds the inner tube. The outer tube is also made of Styrofoam and hot glue, but it's covered in a blanket of multilayer insulation (MLI) instead of aluminum duct tape. The MLI consists of three alternating layers of aluminized space blanket and wedding veil material, and is similar in design to the MLI blankets used in real satellites.

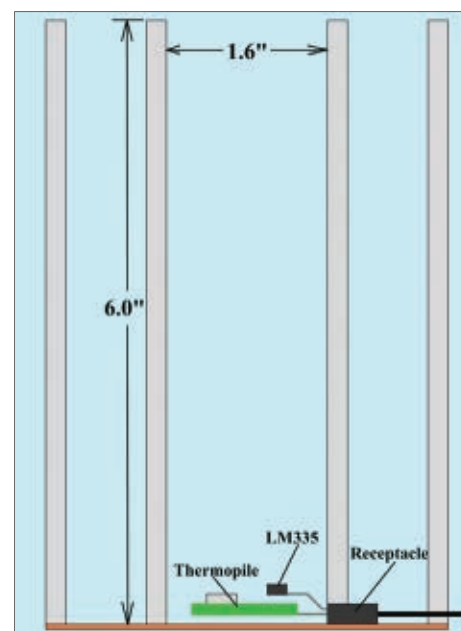
■ The Cellfoam and aluminum tape inner tube. You can see the socket and wiring harness protruding from the bottom of the tube.



■ Three sides of the outer tube have been glued to each other and the infrared telescope's back plate. The tubes don't make contact, thereby limiting their ability to transfer heat to each other.

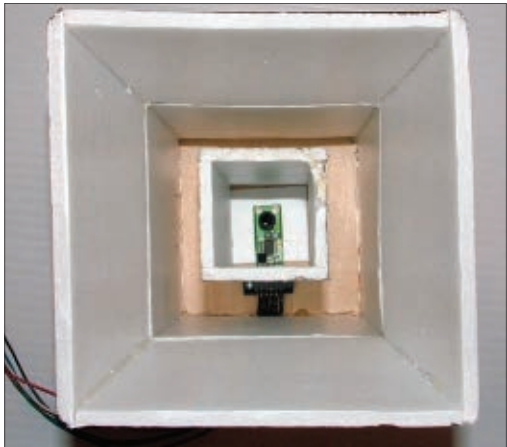


■ This is a cross section of the original near space infrared telescope. Since then, a sun shade was added to the telescope and the infrared thermometer was switched to the 10 degree FOV version (from the original 90 degree FOV).





After completing the nested tubes, I realized they needed an additional protection from sunlight that might enter the tubes when the telescope pointed close to the sun. So, I added a cap — called the sun shield — to the front of the telescope and covered it in aluminum duct tape.



■ Looking down the barrel of the near space infrared telescope. In a future modification, I'll probably wrap the interior faces of the nested tubes in aluminum tape.



■ This is the near space infrared telescope as it's currently mounted to a near spacecraft. The telescope points up at a 45 degree angle to avoid looking at the sun and the balloon. Ideally, it will only see the sky.

PROGRAMMING

Using the infrared thermometer takes two programming steps. The first is to program the infrared thermometer to continuously collect and transmit temperature reports. Then, the flight computer needs to be programmed to record the thermometer's data. I used a BASIC Stamp 2 and a Homework Board to set up the infrared thermometer with this code:

```
LOW 0
PAUSE 5
INPUT 0
PAUSE 50
DEBUG "Start", CR
FOR slave = $01 TO $7F
  SEROUT 0,396,[0,"!TEMW",$5A,$21,$1,$1]
  SEROUT 0,396,[0,"!TEMW",slave,$2E,$5A,"z"]
  PAUSE 150
NEXT
DEBUG "Done"
```

The Melexis infrared thermometer communicates over an SMBus. Like an I²C bus, several devices can hang off an SMBus and take turns communicating with the master device. Instructions for individual infrared thermometers hanging off the SMBus are sent as commands to the specific thermometer and stored in specific memory locations in each slave thermometer. Since the commands are saved in EEPROM, the thermometers begin operating as instructed when they are powered up.

The short program above sends two commands to the infrared thermometer. The first command is stored in memory location \$21 and is an instruction to read data every 10 ms in non-sleep mode, and every one second in sleep mode. The second command is stored in memory location \$2E and is an instruction to continuously output temperature data in a low power mode. After running this program, the near space infrared thermometer begins to continuously transmit temperature data.

I used a PICAXE-based flight computer for the two near space missions my near space infrared telescope has flown to date. The code I used to record data from the thermometer was:

```
serin [2000, Save_Thermo_Data],
1,T4800_4,("M"),lowbyte,lowbyte,highbyte,index
```

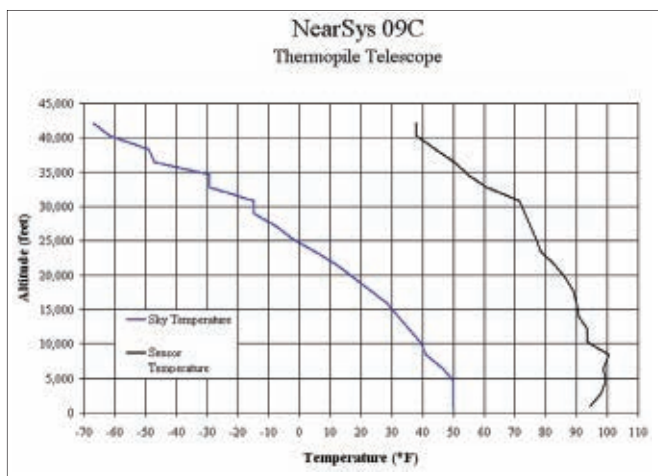
This line of code monitors the serial communication from the thermometer and waits for the letter M before storing data. Following the M are four bytes of data; only the second and third bytes are saved. The resulting word (two bytes of data) is the temperature that the thermometer sees. Once loaded into a spreadsheet, the readings are divided by 50 to convert them into Kelvins. There's a lot of resolution in the data, but you must store one word readings from the telescope.

SAMPLE DATA

My near space infrared telescope has flown on two missions so far. In both cases for some unknown reason, the flight computer stopped recording data from the telescope. The infrared thermometer continues to produce data in testing after recovery, so the unit has not been damaged. Is it a result of the cold temperatures in near space? On the first mission, the telescope reported steadily decreasing sky temperatures. There was a slight temperature inversion at 8,000 feet that does not appear to have affected the telescope's readings. So, I concluded air temperature was not an influence in the infrared thermometer's readings.

On the second mission, the near spacecraft ascended into a bank of low altitude status clouds. The telescope reported a slightly decreasing sky temperature as it approached the cloud base. A weather station onboard this mission reported an air temperature of 29 degrees at the cloud base and a relative humidity of nearly 100%. All of these readings confirmed that the air temperature at the cloud base was indeed 29 degrees. The infrared telescope was therefore reporting a

■ On a mission last year, the near space infrared telescope produced output until it reached an altitude of 42,000 feet. Notice that the telescope didn't get very cold as it was protected by its nested tube design.



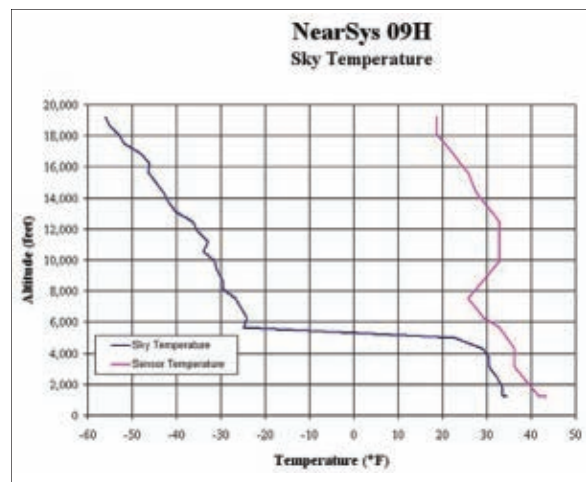
combination of temperatures between the ground and cloud base as it approached. Once the near spacecraft broke free of the clouds, the telescope began measuring the temperature of an air column reaching into space. There was a slight temperature inversion beginning at 8,000 feet again; it did not affect the telescope. If it turns out the thermometer stops producing output because it gets too cold, then I will need to heat the base of the telescope in future missions. I feel comfortable with this alternation since it appears the output of the infrared thermometer is not strongly affected by heat.

FUTURE UPGRADES

After I successfully collect data for an entire near space mission, I plan to perform two additional experiments with the infrared telescope. In the first, I'll attach the telescope to the near spacecraft upside down. This experiment will measure the air temperature below the near spacecraft as a function of altitude. I'd like to correlate those results to air temperatures above the near spacecraft. I also hope to see thermal effects related to the land beneath the near spacecraft. For that experiment to be effective, a video camera needs to be mounted along side the telescope. Then, a comparison of blips in the thermal data can be compared to images of the land.

For the second experiment, I plan to mount the telescope to a scan platform. This will let the telescope scan from the horizon to the zenith throughout a mission. I'd like to compare how different elevations

■ On the second mission, the telescope stopped producing data at an altitude just above 19,000 feet.



above the horizon chill during an ascent into near space. To ensure the sun does not affect the results, I have developed a sensor to locate the sun's heading in relationship to the near spacecraft. This will allow the flight computer to only scan and collect data while the telescope is pointed away from the sun.

WRAP-UP

That's it for the near space infrared telescope. I hope you get a chance to use the infrared thermometer unit on a near space mission, a robotics project, or an amateur science project. For example, you can use the infrared thermometer in a robotic fire fighting competition. Or, perhaps you can attach it to an astronomical telescope aimed at different spectral classes of stars. Ideas like this should keep everyone busy for quite a while.

Onwards and Upwards,
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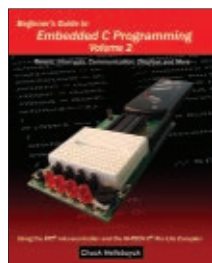
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In this "Volume 2," Chuck takes the reader to the next level by introducing how to drive displays, how to use interrupts, how to use serial communication, and how to use the internal hardware peripherals of the PIC16F690 microcontroller such as SPI, PWM, and timers. When you have finished reading this book and completed the projects, you'll be well beyond the title of Beginner!

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The components that are added to the PICKit 2 that Chuck uses in his new book can also be purchased through the Nuts & Volts Webstore.

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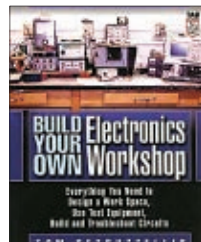
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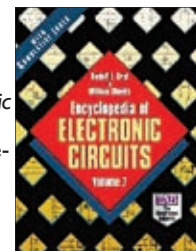
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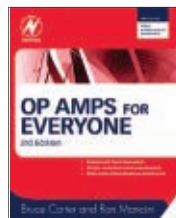
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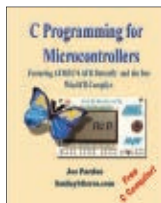
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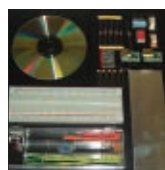
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by Joe Pardue
As talked about in the
Nuts & Volts June issue,
"Long Live The Serial Port"



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Kit \$69.95

This is a cookbook for communicating between a PC and a microcontroller using the FTDI FT232R USB UART IC. The book has lots of software and hardware examples. The code is in C# and Visual Basic Express allowing you to build graphical user interfaces and add serial port functions to create communications programs.

The Virtual Serial Port Parts Kit and CD

(also available, above right)

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The Getting Started Combo includes: Getting Started in Electronics by Author Forrest Mims and the DIY Electronics Kit. In his book, Mims teaches you the basics and takes you on a tour of analog and digital components. He explains how they work and shows you how they can be combined for various applications. The DIY Electronics Kit allows for the hands-on experience of putting circuits together -- the kit has over 130 parts! No soldering is required and it includes its own 32 page illustrated manual. **Combo Price \$62.95 Plus S/H.**

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PROJECTS

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Ready to move on from eight-bit to 16-bit microcontrollers? Well, you're in luck! In the December 2009 *Nuts & Volts* issue, we introduced a new, "16-bit Micro Experimenter."

The kit comes with a CD-ROM that contains details on assembly, operation, as well as an assortment of ready-made applications. New applications will be added in coming months.

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"Double Wide" Sun Tracker Kit



The Double Wide Sun Tracker is one of the great projects from the new series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 4 and 5, he teaches you how to get the most out of your PVs within the full day of sunlight. For kit details, please visit our website.

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DC-to-DC Converter Kit



As seen on the March 2009 cover



"Roll Your Own" Transformer, that is!
 With this project, you design and wind a transformer and use it to get +12V and -12V from a 9V battery from the DC-to-DC converter.

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Extra Cores and Bifilar can be bought separately.

NixieNeon Clock Kit



Sale!

Using Neon and Nixie bulbs, this clock displays the precision movement of time and is programmable to display "Time Chaos" at different intervals. The NixieNeon Clock then resets itself to the correct time in an eye-catching ballet of luminosity.

The PCB is 7.25"x 7.25" and consists of over 400 components.

Reg \$195.95
Sale Price \$159.95

PCBs can be bought separately.

Now With New Code!

Transistor Clock Kit



If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see page 42, this issue.

Reg \$225.95
Sale Price \$199.95

PCBs can be bought separately.

rCube Talking Alarm Clock Kit



As seen on the May 2009 cover



Available in blue, black, red, and green. All components are pre-cut & pre-bent for easier assembly and the microcontrollers are pre-programmed with the software.

Kits also include PCB, AC adapter, and instructions on CD-ROM.

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Nixie Tube Clock Kit



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October 2006

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Kit includes article reprint, complete instructions and parts list.

Das Blinkenboard Kit

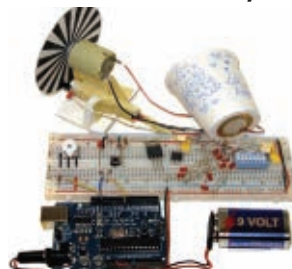
This kit includes a pre-programmed ATtiny84 microcontroller that sports eight software PWM channels to control motor speed and light brightness. Jumper selectable patterns can be used to operate motors, solenoid valves, relays.

Expand your board with the "Der Magnetfelder Detektor" componet pack.



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Arduino Project Kit From the Smiley Workshop



By Joe Pardue

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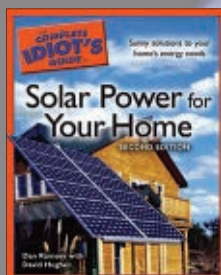
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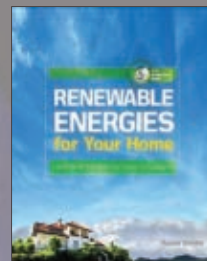


Renewable Energies for Your Home

by Russel Gehrke

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Build Your Own Plug-In Hybrid Electric Vehicle

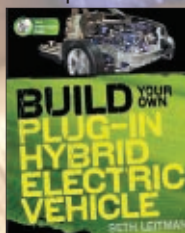
by Seth Leitman

A Step-by-Step Guide to Building a Plug-In Hybrid Electric Vehicle from the ground up

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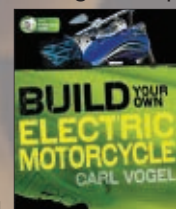
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by Chuck Hellebuyck

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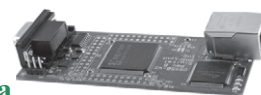
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NEW PRODUCTS

Continued from page 29

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>>> QUESTIONS

Stuttering Discs

I have CD and DVD players which, when playing certain discs, will stutter, skip, cut in and out, and sometimes abort the playing altogether. It only does it on some discs, and at the same place on these discs. However, these same discs will work on other players just fine. On at least one player, the problem got progressively worse, and had trouble with discs it played without errors in the past. Is there a way to repair this? Cleaning the lens and disc sometimes helps, but not always. I am playing only commercially made CDs and DVDs, not home burned ones.

#1101 **Michael Kiley**
Crestwood, IL

Tunable Sine Wave Generator

I am working on a project to provide 100 inexpensive, disposable electronic devices for a church. Each device requires a cheap, low-distortion, parts-stingy sine wave generator, easily tunable using only one pot from 1 kHz to 1 MHz, preferably using one common and cheap IC like an op-amp or a few transistors. To be compact, the parts count should be under about a dozen. I have plenty of XR8038 and XR2206 function generator ICs, but they are far too costly for this project. My experiments have produced only square waves or triangular waves, but meet all my other criteria. What is the best sine wave design?

#1102 **John Williams**
via email

RA2892 Datasheet

Can anyone help me find the datasheet for the following component: RA2892 from Raytheon? Also what is an equivalent (cross reference) that I can use?

#1103 **Mohamed Fathi**
Egypt

Speaker Hum

I have a problem with my speakers humming on my desktop PC. I think this may be wall wart related but not 100% sure.

Is there a way to fix this problem or do I need to buy a new set of speakers?

#1104 **John Sparozich**
Philadelphia, PA

Automotive Speed Sensor

I recently replaced the trans in my Ford van. Somewhere between 00 and 02 model years, Ford changed the speed sensor output to the PCM, but I have an analog gear driven sensor. The newer sensor is digital (variable reluctance). I need to change the signal back to analog so the speedometer, ABS, and cruise will work. Is there a device to do it, or is it even possible?

#1105 **Chris Camp**
Dalton, GA

Design/Test Software

I've had electronic engineering schooling back in the 80's and have tinkered a little since then. I've never had a computer until now and would like to know some free or reasonable circuit design/test software download sites to tinker with.

#1106 **Jeffrey Howard**
Alexandria, IN

>>> ANSWERS

[#9091 - September 2009] Battery Charging

I have a door access control system that uses 110 VAC normally but has a 7 Ah battery for backup power. This only offers a very short time

period of battery power should the AC fail. Its built-in power supply/charger is rated at 1A. My question is, what are the ramifications of substituting a much larger battery for the 7 Ah one? Aside from the possibility that once depleted, a higher amp hour battery would take longer to recharge and possibly not even recharge fully, are there any other detrimental possibilities to the system or the battery?

#1 There are several issues with a larger battery:

1. You have correctly stated that a longer recharge time will occur if charging current is not increased. Most chargers I have seen are based upon the LM317 as a current limiter/voltage regulator. You can find charger circuits in the National Semiconductor LM317 datasheet. Many of them will limit current and turn off accurately at a certain voltage. The battery will recharge fully, but will simply take longer to recharge (roughly with Ah capacity, twice as large, charge time multiplied by two, etc). You can easily measure the charge current with a DMM, but both batteries should be in the discharged state. You should not see any appreciable difference.

2. The larger battery will provide considerably higher short circuit currents to the connected circuits and needs to be properly fused.

3. It is common for larger batteries to be installed separate from other equipment due to their particular requirements for venting and corrosion they can cause. You were most likely looking at a non-vented, gel-type sealed lead-acid battery which

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving technical problems. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted

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Walter Heissenberger
Hancock, NH

#2 If your built-in charger is tailored to your 7 Ah battery, it may overheat when you attempt to charge a higher capacity battery. Frying the circuit and burning your house would be the worst case scenario. However, this can be avoided by simply putting a current-limiting resistor in series with the charger in order not to exceed the 1A rating. You should measure the maximum voltage output of the charger. Suppose the charger outputs 14V maximum which would normally be used to charge a 12V battery. To limit the charging current to a maximum of 1A, you need $R = 14V/1A = 14$ ohms resistor. The power rating of that resistor should be $P = 14V \times 1A = 14$ W. Using this, you will be able to use the old charger to trickle charge a higher capacity battery.

Claude Bouchard
Ontario, Canada

[#9092 - September 2009]

Antenna Coupling

I want to couple a 470-490 MHz Yagi and a wide band omnidirectional antenna together and use a single run of coax into my house. Can I simply use a coax tee connector?

#1 Any sensor — antennas included — will perform best when not directly coupled to other sensors. So, you want to have independent access to the signal from each antenna. After detection and treatment of each signal, then you can combine the signals in any wanted manner if so desired. That being said, you can still do a single run of cable if you use dual coaxial cable. You can get 250 feet of dual RG6/U Quad shield coaxial cable for less than \$60 if you shop a little. See an example item #PGN-28443066 at PriceGuideNet.com.

Claude Bouchard
Ontario, Canada

#2 If all you are going to do is 'listen' — receive only — you can use any good quality splitter/divider to combine the antennas. Just using a tee connector will mess up your impedance match; 75 ohm devices used in TV will work okay for that purpose. Use a quality unit, not just a passive resistive splitter. Now, if you plan to transmit using those antennas, you will need to rethink.

You will need a diplexer, duplexer, or circular combiner. A product that works very well is marketed by MFJ Enterprises, model MFJ-916B. It will allow you to transmit and receive on 350-540 MHz and also on 1.3-225 MHz simultaneously with separate

antennas without damage to either radio and very little insertion loss (www.mfjenterprises.com). Similar products are sold under other brand names. It is 50 ohms in and out, and can be obtained with either UHF or Type N connectors. Works both ways, 2 in 1 out, or 1 in 2 out. Using a unit at the antennas and another one at the radio end allows use of a single coax to combine both systems.

Rod Hogg/REVCOM Electronics
Scott City, KS

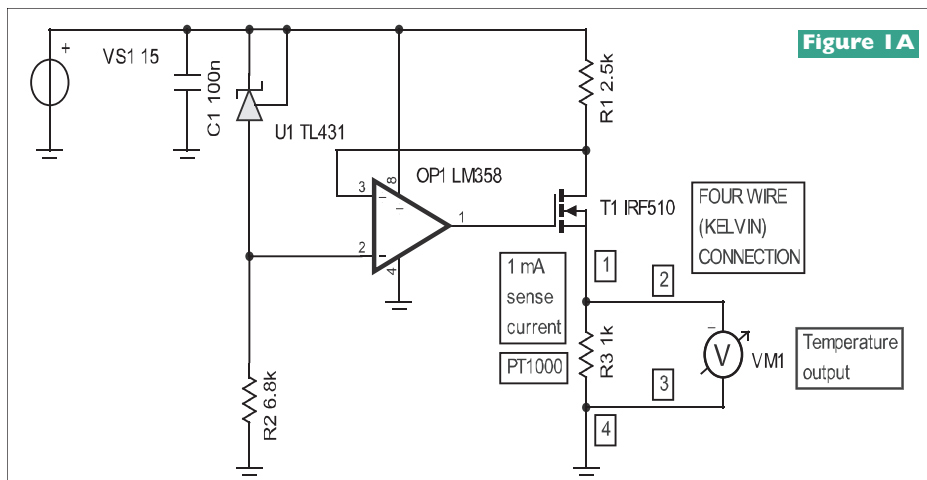
[#9093 - September 2009]

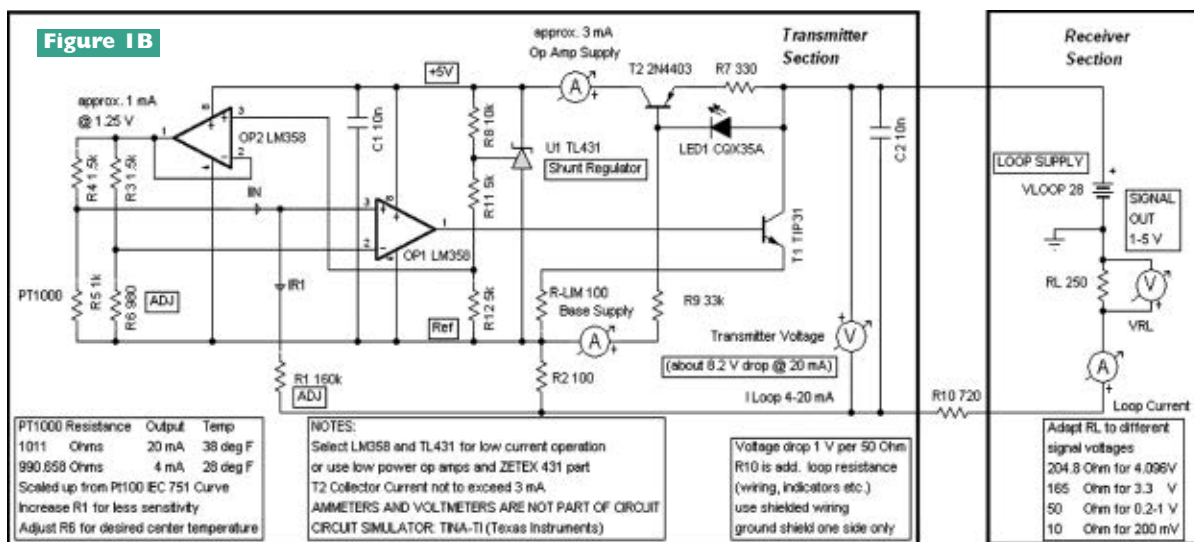
Current Source

I understand that you can use a voltage regulator to work as a current source. Is there a limitation on the load that the current will pass through? I would like to pass the current through a platinum temperature sensor and a fixed resistor of known value to determine the temperature of the sensor. The current suggested is between 0.1 and 1.0 mA to avoid self heating. If the fixed resistor has a value of 10,000 ohms and I have a current of 0.5 mA, then the voltage drop across the resistor is 5.0 volts. Would this mean that I would need a power source greater than the voltage drop across the resistance plus the voltage output of the regulator?

Here are two different approaches. Both will work fine.

1. What you may be interested in is not an industrial current loop, but rather a four-terminal Kelvin arrangement (**Figure 1A**). A constant current is injected into a sense resistor (a precision platinum resistor), usually referred to as a PT100, PT500, or PT1000. The output of the resistor is a voltage, which follows the temperature very accurately. The voltage output is taken from the sense resistor, so that the sense current does not flow through these wires. Otherwise, it would add an error with wire length (sometimes three wire arrangements





The cells warm due to the recombination of generated oxygen and hydrogen. This warming above ambient can be sensed with a thermistor to terminate charging as in the circuit of **Reference 1**. You may want to consider that circuit after you get the simple

are used, since the error can be determined and compensated for). If larger temperature ranges need to be covered, then linearization should be used (usually a microcontroller takes care of this task). Although voltage regulators can be used as constant current sources, the adjustment pin input current is rather large (typ. 50 A) and not necessarily constant. A better solution is an op-amp with MOSFET output. The MOSFET has a miniscule gate current and the result is an accurate and constant current.

2. You may really want to use a current loop due to the inherent benefits (wire length does not matter, simplicity, and reliability). **Figure 1B** is based upon a compensated bridge circuit and Vos is trimmed out (not Vos drift). Only four milliamps are available as a minimum to work with, therefore current consumption is a problem. Either selected low current parts or specialty parts are required. Workaround: Use 10-50 mA, or use a supply at the transmitter. Run the circuit simulator Tina-TI in transient mode with 20 ms run-time to get a feel for how the circuit works (also see Texas Instruments/Burr-Brown XTR115, an integrated circuit incorporating all the functions).

Walter Heissenberger
Hancock, NH

drills, 12.5V through 19.5V. Most of the charging stations are minimal at best, only lasting a few months. Does anyone have a good schematic for a battery charger that can charge any of the drill batteries up to and including the 19.5V battery?

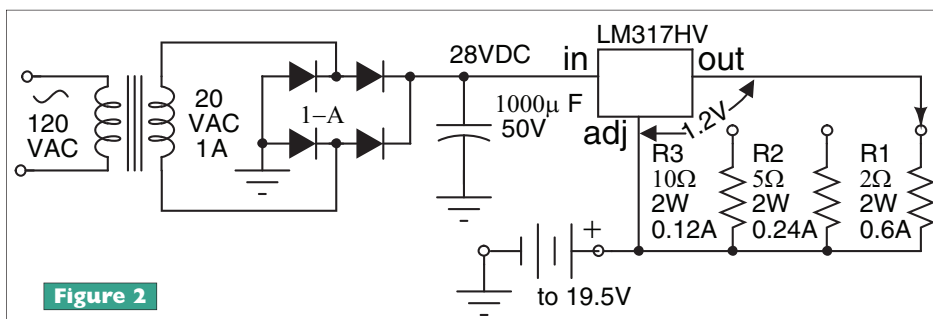
Figure 2 shows a 20 VAC transformer producing 28V rectified filtered DC (1.4 x 20) at the capacitor. The LM317 and switch selected resistor are a constant current regulator based on an adjustable LM317 voltage regulator. The LM317 outputs 1.2 volts between the output and the adjustment pins. Therefore, 1.2V across the 10 ohm resistor (if it were selected) means that 1.2/10 = 0.12A flows through R3 and the charging battery. In a similar manner, 0.24A or 0.6A may be switch selected at R2 or R1, respectively. A charging current of 0.12A should charge the battery in approximately a day. Charging a Ni-Cad battery is endothermic, meaning that it gets slightly cool. Once charging is finished, overcharging is exothermic.

charger presented here working. However, the circuit in **Reference 1** is only designed to charge a 12V battery. Therefore, it must be modified by substitution of the component values shown here. The LM317 here replaces the 7085 there. In addition, a 7812 volt regulator (which it uses) needs to accommodate a higher voltage on the input side. A Fairchild KA7812AE, rated at 35V input is appropriate. Measure the 28 VDC without a charging battery to verify that it does not exceed 35V.

The reason for terminating the charge is that cell life is increased. Termination is mandatory at high charging currents because high temperatures can cause venting of generated gasses. Termination at low charging current is not mandatory as evidenced by a warm as opposed to a hot battery.

Reference: [1] G. Forrest Cook,
www.solorb.com/elect/tmpchrg/index.html

Dennis Crunkilton
Abilene, TX



[#9095 - September 2009] Drill Charger

I have several battery-powered



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Output Current	50mA Vpeak=100mA	50mA Ipeak=50mA
Harmonic Wave distortion	-65dBc(1KHz), -53dBc(100KHz)	-50dBc(1KHz), -40dBc(10KHz)
Low Pass filter	5MHz, 1MHz, 100KHz, 10KHz 1KHz Programmable	no
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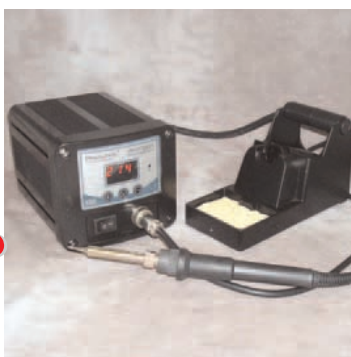
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